A PROSPECTIVE ANALYSIS OF FUNCTIONAL OUTCOME OF DISPLACED DISTAL FEMUR FRACTURES INTERNALLY FIXED WITH DISTAL FEMUR LOCKING COMPRESSION PLATE

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CERTIFICATE

This is to certify that **Dr. N.GANESH**, Postgraduate student (2010-2013) in the department of Orthopaedics, Government Mohan Kumaramangalam Medical College, Salem has done this dissertation "**A PROSPECTIVE ANALYSIS OF FUNCTIONAL OUTCOME OF DISPLACED DISTAL FEMUR FRACTURES INTERNALLY FIXED WITH DISTAL FEMUR LOCKING COMPRESSION PLATE"** under my supervision in partial fulfillment of the regulation laid down by the Tamilnadu Dr. M.G.R Medical University, Chennai for M.S., (Orthopaedics) degree examination to be held during April 2013.

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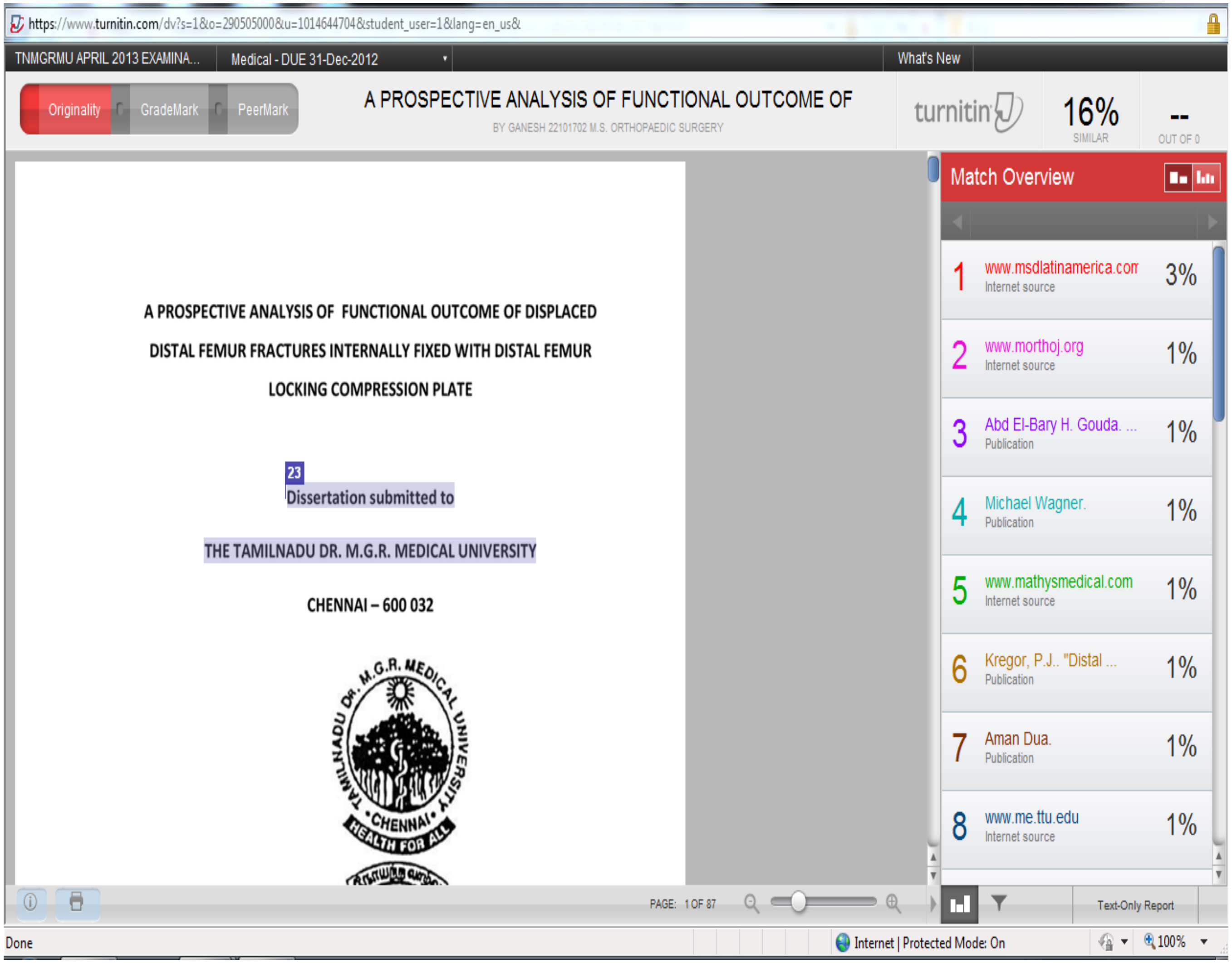
DECLARATION

I, **Dr.N.GANESH**, solemnly declare that this dissertation titled "**A PROSPECTIVE ANALYSIS OF FUNCTIONAL OUTCOME OF DISPLACED DISTAL FEMUR FRACTURES INTERNALLY FIXED WITH DISTAL FEMUR LOCKING COMPRESSION PLATE"** is a bonafide work done by me, at Government Mohan Kumaramangalam Medical College, Salem between the period 2010-2013, under the guidance of my unit Chief **Prof. Dr.A.D. SAMPATH KUMAR M.S.(Ortho)**, Associate professor of Orthopaedic Surgery. This dissertation is submitted to Tamilnadu Dr. M.G.R Medical University, towards partial fulfillment of regulation for the award of M.S.Degree (Branch – II) in Orthopaedic Surgery.

PLACE: DR. N. GANESH

DATE:

Originality Report



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CONTENTS

INTRODUCTION

Fracture of the distal femur involves the distal femoral metaphysis and the femoral condyles. They represent about 6% of all femoral fractures. If hip fractures are excluded, 31% of femoral fractures involve distal portion[23,24]. With the increased incidence of high energy trauma, especially those caused by Road traffic accidents, the occurrence of these difficult to treat fractures have also increased. Hence there is a growing need for effective management of these injuries. Adding to the challenge is the occurrence of these fractures in older age group with osteoporotic bones, due to the present trend of increased life expectancy seen in developed and even developing countries.

In treating these fractures, certain critical components of distal femur anatomy should be considered which will be discussed in detail in subsequent sections. Very frequently these fractures involve the adjacent knee joint, thus greatly increasing the requirement of precise anatomic reduction and careful handling of soft tissue.

It is not uncommon for these injuries to be associated with other long bone and pelvic fractures as the causative forces are usually due to high velocity impact. Hence the functional outcome of these patients is always guarded and may be compromised if a wholesome approach to treatment is not adopted.

These fractures predominantly occur in two age groups. The first group consists of younger patients between 20 and 35 years of age, mostly males who sustain a distal femoral fracture as a result of high velocity trauma due to Road traffic accidents. In these cases, fractures occur as a consequence of direct application of force to the flexed knee joint. A familiar patho mechanism is the “dash board injury” whereby an impact on the flexed knee forces patella back in between the femoral condyles like a wedge to produce the injury.

The second group consists of patients mostly females, between 60 and 75 years of age .In these patients, a low energy trauma involving osteoporotic bones is enough to cause the injury.

The choice of treatment has evolved from predominantly conservative methods to the now popular surgical methods, mainly due to the technological advances in implant designs, availability of better tools of fracture reduction, improved surgical techniques and increased expectation from the patients regarding functional outcome.

New concepts in terms of surgical techniques include MIPO- Minimally invasive percutaneous plate osteosynthesis, and TARPO- Transarticular joint reconstruction and indirect plate osteosynthesis.

Newer implants like Distal femur Locking compression condylar plates and Less Invasive Skeletal Stabilization system[7,8,9] have almost irrationalized the use of conservative treatment in the management of these fractures and are the most common implants being used today. They offer multiple points of fixed angle contact reducing the chances of varus collapse and providing better stability[15].

AIM OF THE STUDY

The aim of the study is to “Prospectively analyse the functional outcome of displaced distal femoral fractures, internally fixed using Distal Femur Locking Compression Plates” at the Department of Orthopaedics, Government Mohan Kumaramangalam Medical College Hospital, Salem between May 2010 and November 2012.

REVIEW OF LITERATURE

Historical Review

Upto the 1960's non-operative treatment methods like traction and cast bandaging were more popular than operative methods. However, the patient was exposed to the risk complications associated with prolonged bed rest such as DVT, pulmonary complications, osteoporosis, decubitus ulcers, generalized muscle atrophy and deconditioning. This led to the quest for better surgical techniques which could allow early mobilization of the patient.

Stewart, Sisk and Wallace in 1966 and Neer in 1967 conducted clinical studies and reported better results with non operative than operative methods in terms of functional outcome.

A first case series of 112 patients published by AO group in 1970 established improved outcome obtained by operative treatment. In 1980, Seinsheimer recommended traction followed by cast bracing for extra articular distal femur fracture and operative treatment for all intercondylar fractures. Further studies reported in quick succession showed improved outcome of operative treatment.

Olerud in 1972 reported 95% satisfactory results in Distal femur fractures treated with Fixed angle blade plate.

In 1979, Schatzker and Lambert highlighted the inadequacy of mechanical stability of blade plates and the technically demanding nature of surgery.

Ostrum and Geel showed excellent and satisfactory results in 87% patients treated with DCS. Then came the Condylar buttress plate, but it had limitations of decreased stability and varus angulation. Subsequently, double plating for comminuted unstable fracture of distal femur was used. In 1991, Henry Tager and Seligron used supra condylar nail for supracondylar fractures without intra articular extensions.

LCP was approved as standard AO plate in early 2000. Very soon LISS technique was developed which allowed higher elastic deformation than other systems, though it was technically demanding.

Anatomy[23,24,26,27]

The distal end of femur is characterized by two large condyles, which act as bearing surface for transmission of weight to the tibia. They articulate with the proximal tibial condyles. The femoral condyles are separated posteriorly by theintercondylar fossa .They join anteriorly where they articulate with the patella.

The surfaces of the condyles that articulate with the tibia are rounded posteriorly and become flatter inferiorly. On each condyle, a shallow oblique groove separates the surface that articulates with the tibia from the more anterior surface that articulates with the patella. The surfaces of the medial and lateral condyles that articulate with the patella together form a V-shaped trench, which faces anteriorly. The lateral surface of the trench is larger and steeper than the medial surface. Lateral view of the distal femur shows that the anterior half of the condyles is aligned with the shaft of the femur. Axial view shows the condyles are wider posteriorly, thus giving a trapezoidal shape to the distal femur.

The lateral condyle is flat and though less prominent, it is more massive and more in direct line with femoral shaft. Hence, it transmits more body weight to the tibia. The lateral condyle is broader than the medial condyle and projects forward helping to stabilize the patella. Its most prominent point is the lateral epicondyle. A short groove separates lateral epicondyle posteriorly from the articular margin.

The attachments on the lateral condyle are

a) The fibular collateral ligament of the knee joint

b) The popliteus tendon

c) The lateral head of gastrocnemius

The medial condyle extends farther distally and is longer than the lateral condyle and is convex medially. Situated in the uppermost part of the condyle is Adductor Tubercle.

The attachments on the medial condyle are

a) The tibial collateral ligamentof the knee joint

b) The adductor tubercle at lower end of medial supracondylar line receives the insertion of hamstring part (ischial head) of adductor magnus.

c) Medial head of gastrocnemius

The Intercondylar fossa separates the two condyles distally and behind. It is intracapsular but is largely extrasynovial. The walls of the fossa bear two facets for the superior attachment of the cruciate ligaments, which stabilize the knee joint. The wall formed by the lateral surface of the medial condyle has a large oval facet, which covers most of the inferior half of the wall, for attachment of the posterior cruciate ligament .The wall formed by the medial surface of the lateral condyle has a posterosuperior smaller oval facet for attachment of the proximal end of the anterior cruciate ligament. The fossa is limited anteriorly, by patellar surface and posteriorly by Inter condylar line, which gives attachment to capsular ligament and oblique popliteal ligament. The fossa's anterior border gives attachment to the Infrapatellar synovial fold.

The zone between the femoral condyles and the junction of metaphysis and femoral shaft constitutes the supracondylar area of femur. Thus it constitutes the area from the proximal end of the condyles to an area upto 9cm from the articular surface. It contains the lateral and medial supracondylar line (continuous with linea aspera), a popliteal surface and an anterior surface. The short head of biceps femoris and lateral – intermuscular septum are attached to the lateral supracondylar line in its proximal two – thirds where it is most prominent. The distal third of the line has a small rough area for plantaris. The medial supracondylar line gives attachment to vastus medialis in its proximal two – thirds. It is crossed by the femoral vessels entering popliteal fossa. It is sharp in its distal third where the membranous expansion of tendon of the Adductor

Magnus is attached. The popliteal surface forms the proximal floor of popliteal fossa and is covered by variable amount of fat separating the artery from bone.

Nutrient Artery to femur

Derived from the second perforating artery, it enters the nutrient foramina located on the medial side of the linea aspera and is directed upwards. There is no artery exclusively for the distal femur, but it gets abundant blood supply through genicular vessels, of which the middle genicular supplies the cruciate ligaments.

Ossification

After the clavicle, the femur is the first long bone to ossify.

1 primary centre - Shaft appears in 7^{th} week of intrauterine life

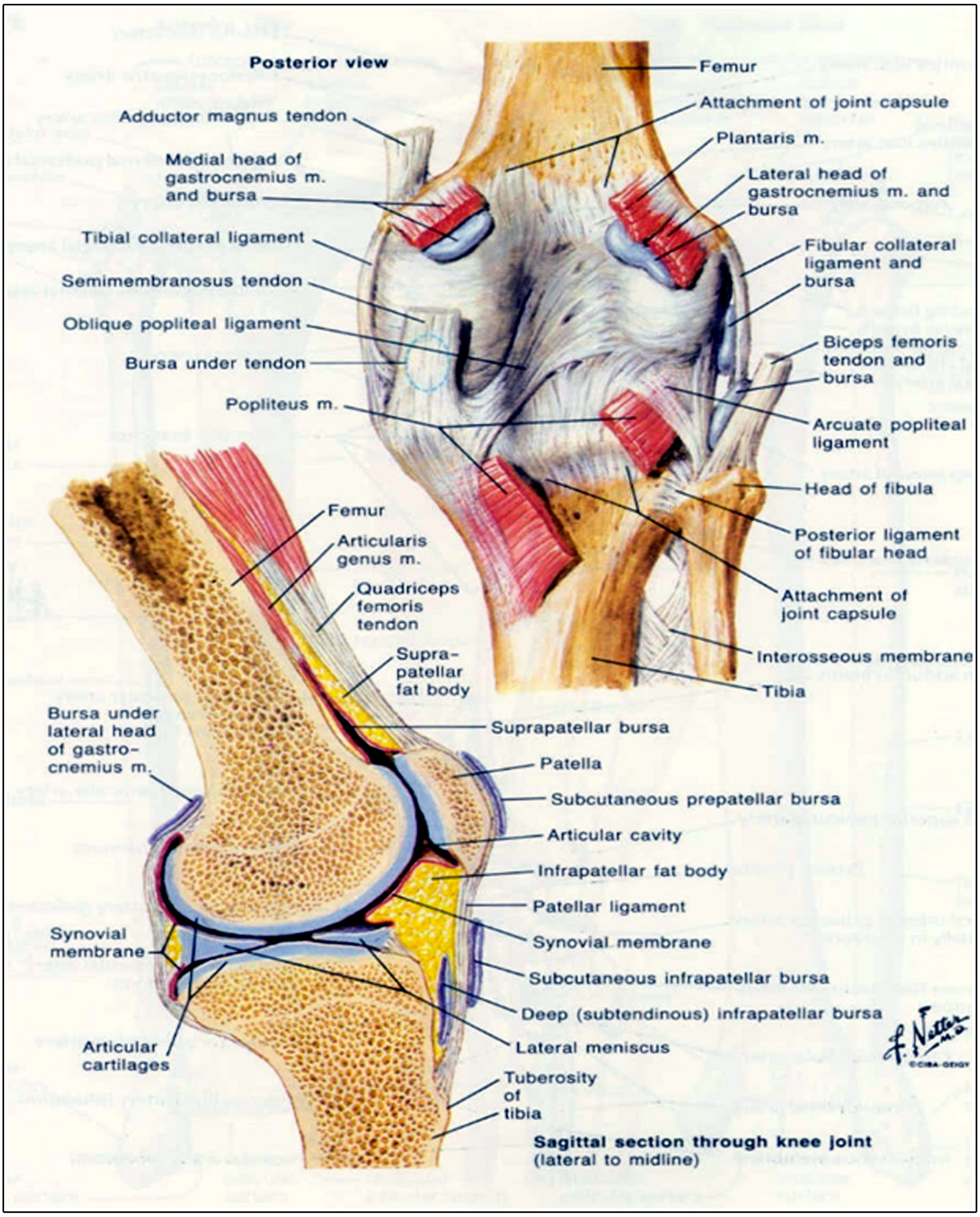
4 secondary centres

- Lower end - End of 9th month of I.U. life(the major growing end of the bone)
- Head - During first 6 months of life

- Greater trochanter- During 4th year
- Lesser trochanter - During 12th year

There are 3epiphysis at the upper end and one at the lower end, that fuse by 18-20 years. Patella ossifies from many centres which appear during 3-6 years of age, fusion becoming complete at puberty.

ANATOMY



Posterior view
Femur
Attachment of joint capsule
Adductor magnus tendon
Plantaris m.
Medial head of gastrocnemius m. and bursa
Lateral head of gastrocnemius m. and bursa
Tibial collateral ligament
Fibular collateral ligament and bursa
Semimembranosus tendon
Oblique popliteal ligament
Biceps femoris tendon and bursa
Bursa under tendon
Popliteus m.
Arcuate popliteal ligament
Head of fibula
Posterior ligament of fibular head
Attachment of joint capsule
Interosseous membrane
Tibia
Femur
Articularis genus m.
Quadriceps femoris tendon
Supra-patellar fat body
Suprapatellar bursa
Bursa under lateral head of gastro-cnemius m.
Patella
Subcutaneous prepatellar bursa
Articular cavity
Infrapatellar fat body
Patellar ligament
Synovial membrane
Synovial membrane
Subcutaneous infrapatellar bursa
Deep (subtendinous) infrapatellar bursa
Articular cartilages
Lateral meniscus
Tuberosity of tibia
Sagittal section through knee joint (lateral to midline)
F. Netter M.D.
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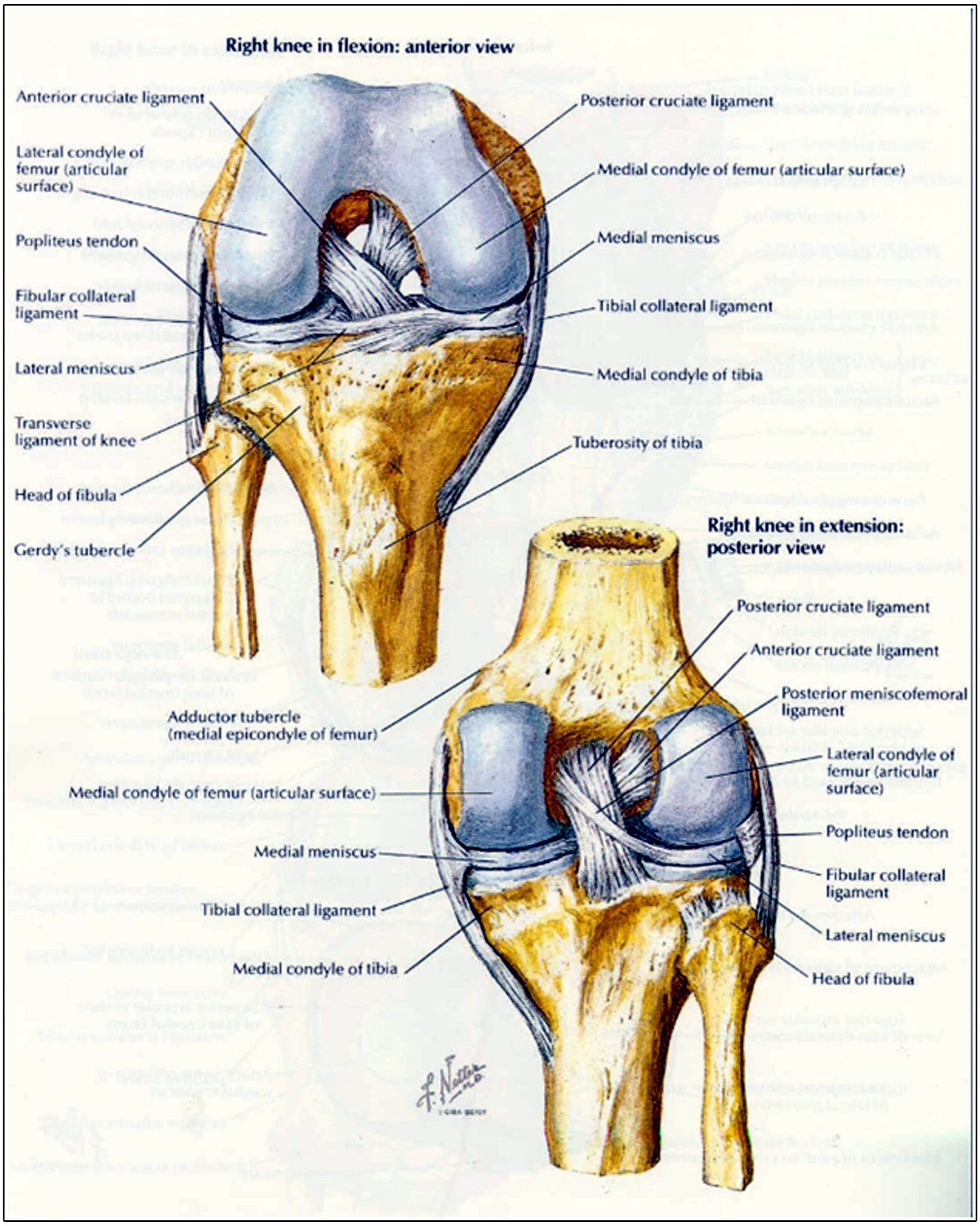
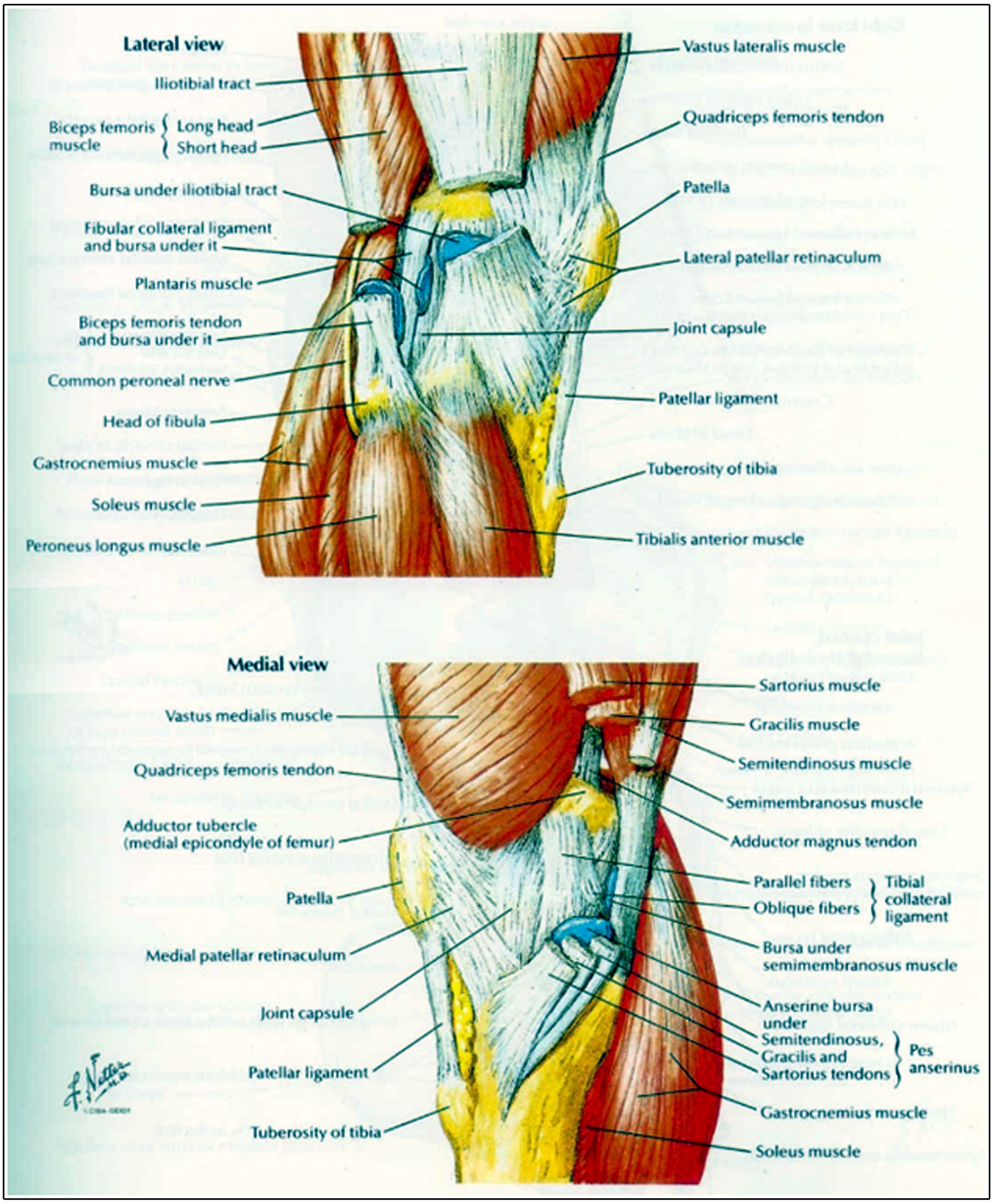
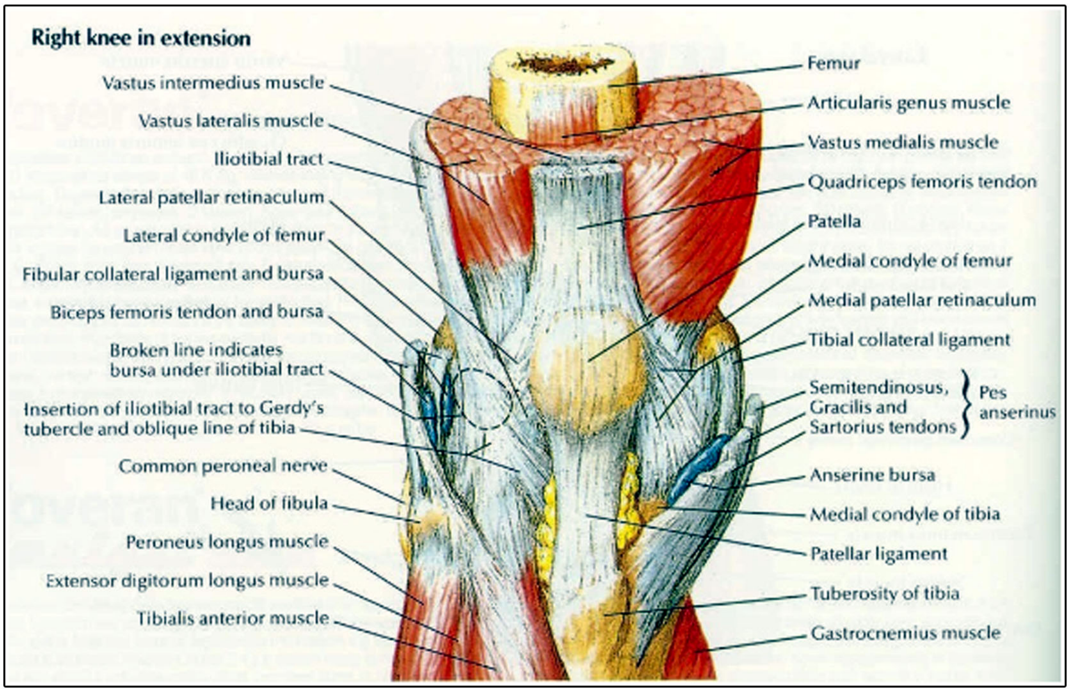


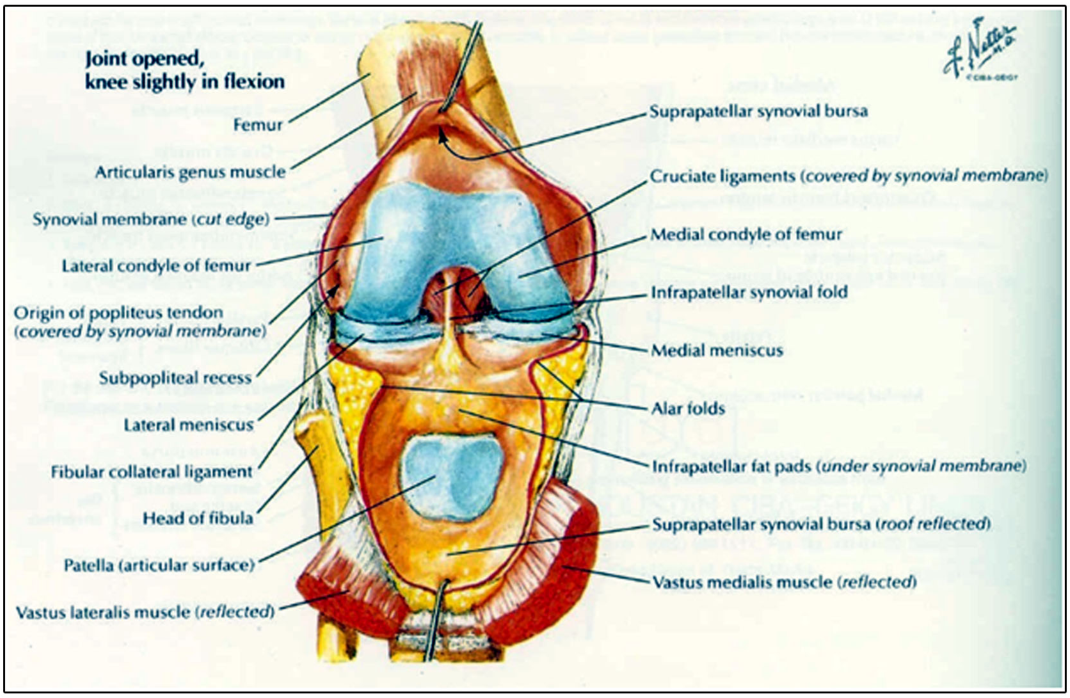
Right knee in flexion: anterior view
Anterior cruciate ligament
Lateral condyle of femur (articular surface)
Popliteus tendon
Fibular collateral ligament
Lateral meniscus
Transverse ligament of knee
Head of fibula
Gerdy's tubercle
Posterior cruciate ligament
Medial condyle of femur (articular surface)
Medial meniscus
Tibial collateral ligament
Medial condyle of tibia
Tuberosity of tibia
Right knee in extension: posterior view
Posterior cruciate ligament
Anterior cruciate ligament
Posterior meniscofemoral ligament
Lateral condyle of femur (articular surface)
Popliteus tendon
Fibular collateral ligament
Lateral meniscus
Head of fibula
Adductor tubercle (medial epicondyle of femur)
Medial condyle of femur (articular surface)
Medial meniscus
Tibial collateral ligament
Medial condyle of tibia



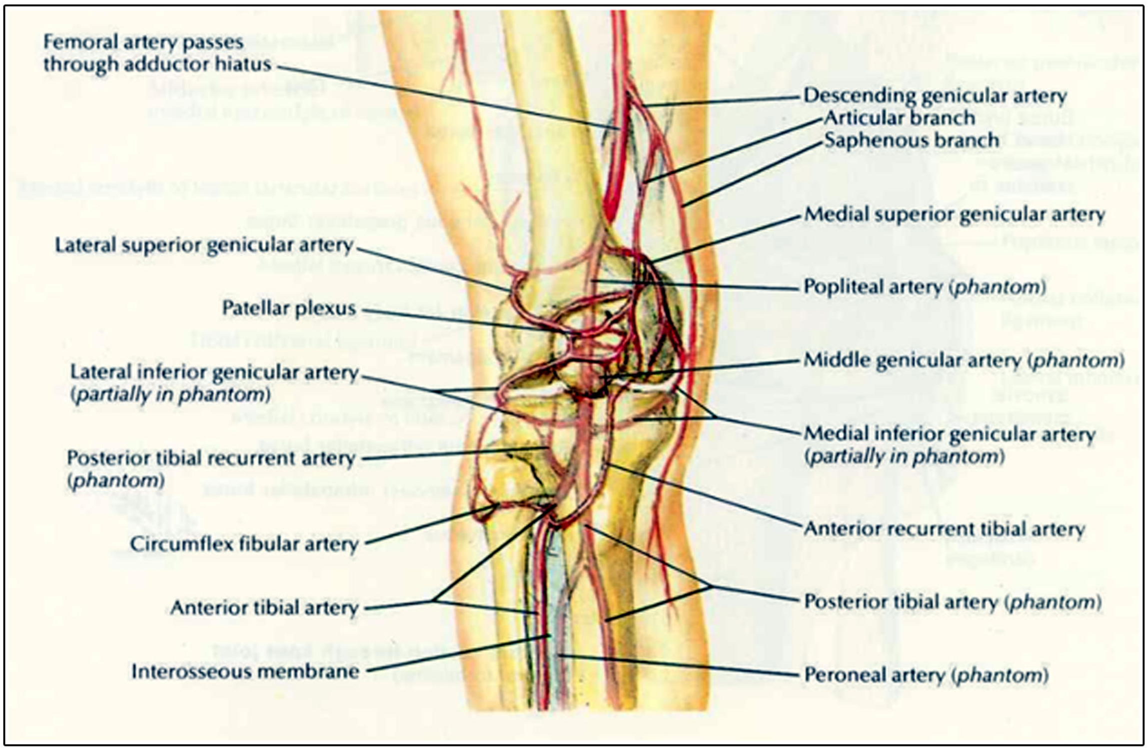
Lateral view
Iliotibial tract
Biceps femoris muscle
Long head
Short head
Bursa under iliotibial tract
Fibular collateral ligament and bursa under it
Plantaris muscle
Biceps femoris tendon and bursa under it
Common peroneal nerve
Head of fibula
Gastrocnemius muscle
Soleus muscle
Peroneus longus muscle
Vastus lateralis muscle
Quadriceps femoris tendon
Patella
Lateral patellar retinaculum
Joint capsule
Patellar ligament
Tuberosity of tibia
Tibialis anterior muscle
Medial view
Vastus medialis muscle
Quadriceps femoris tendon
Adductor tubercle (medial epicondyle of femur)
Patella
Medial patellar retinaculum
Joint capsule
Patellar ligament
Tuberosity of tibia
Sartorius muscle
Gracilis muscle
Semitendinosus muscle
Semimembranosus muscle
Adductor magnus tendon
Parallel fibers
Oblique fibers
Tibial collateral ligament
Bursa under semimembranosus muscle
Anserine bursa under
Semitendinosus, Gracilis and Sartorius tendons
Pes anserinus
Gastrocnemius muscle
Soleus muscle
F. Netter M.D.



Right knee in extension
Vastus intermedius muscle
Vastus lateralis muscle
Iliotibial tract
Lateral patellar retinaculum
Lateral condyle of femur
Fibular collateral ligament and bursa
Biceps femoris tendon and bursa
Broken line indicates bursa under iliotibial tract
Insertion of iliotibial tract to Gerdy's tubercle and oblique line of tibia
Common peroneal nerve
Head of fibula
Peroneus longus muscle
Extensor digitorum longus muscle
Tibialis anterior muscle
Femur
Articularis genus muscle
Vastus medialis muscle
Quadriceps femoris tendon
Patella
Medial condyle of femur
Medial patellar retinaculum
Tibial collateral ligament
Semitendinosus, Gracilis and Sartorius tendons
Pes anserinus
Anserine bursa
Medial condyle of tibia
Patellar ligament
Tuberosity of tibia
Gastrocnemius muscle



Joint opened, knee slightly in flexion
Femur
Articularis genus muscle
Synovial membrane (*cut edge*)
Lateral condyle of femur
Origin of popliteus tendon (*covered by synovial membrane*)
Subpopliteal recess
Lateral meniscus
Fibular collateral ligament
Head of fibula
Patella (articular surface)
Vastus lateralis muscle (*reflected*)
Suprapatellar synovial bursa
Cruciate ligaments (*covered by synovial membrane*)
Medial condyle of femur
Infrapatellar synovial fold
Medial meniscus
Alar folds
Infrapatellar fat pads (*under synovial membrane*)
Suprapatellar synovial bursa (*roof reflected*)
Vastus medialis muscle (*reflected*)



Femoral artery passes
through adductor hiatus
Descending genicular artery
Articular branch
Saphenous branch
Medial superior genicular artery
Lateral superior genicular artery
Popliteal artery (phantom)
Patellar plexus
Lateral inferior genicular artery
(partially in phantom)
Middle genicular artery (phantom)
Medial inferior genicular artery
(partially in phantom)
Posterior tibial recurrent artery
(phantom)
Anterior recurrent tibial artery
Circumflex fibular artery
Anterior tibial artery
Posterior tibial artery (phantom)
Interosseous membrane
Peroneal artery (phantom)

Biomechanics of Distal Femur[28]

The expanded femoral and tibial condyles are adopted for the direct downward transmission of weight. During weight transmission, the two condyles rest on the horizontal plane of the tibial condyles and the shaft inclines downwards and inwards. The longitudinal axis of the diaphysis of femur inclines medially downward, with angle of 9° from vertical. The mechanical axis of femur formed by line between centres of Hip and Knee joint is 3° from vertical. Therefore the long axis of the femoral shaft is inclined at an angle to the long axis of the tibial shaft. This tibiofemoral shaft angle is called the physiological valgus. In sagittal plane, the femoral condyle has a changing radius which decreases from before back. In transverse plane the condyles diverge from before back by angle of 20°.

The axis at which flexion and extension occurs moves backwards in relation to tibia with increasing flexion. However, in coronal plane it lies approximately along the line joining the femoral epicondyles.

The knee joint has features characteristic of both hinge and pivot joint articulation. It allows flexion and extension in the sagittal plane and some rotation when the joint is flexed. The Flexion – Extension movement is a combination of Rocking & Gliding motion. During rotatory movement the medial condyle describes a smaller arc than lateral condyle. The natural deflection outwards of the tibia on femur at the knee produces greater weight bearing stresses on the lateral femoral condyle than on the medial condyle, but because the medial condyle is prolonged further forward than lateral condyle, the vertical axis of rotation falls in a plane nearer to the medial condyle. The lateral condyle is broader in AP and transverse planes and the medial condyle projects distally to a level slightly lower than the lateral condyle. This distal projection helps to compensate for the inclination of mechanical axis in erect position, so that the transverse axis is horizontal. The articular surface of the medial condyle is prolonged anteriorly and as the knee comes into the fully extended position, the femur internally rotate until the remaining articular surface on medial condyle is in contact. The posterior portion of lateral condyle rotates forward laterally thus producing screwing home movement, locking the knee in fully extended position. The surgical anatomy of distal femur is so complex and can present serious problem to the unwary surgeon. When viewed in cross section, the shape resembles a trapezoid with the medial side inclined about 250^{o} and the lateral about 10°. The posterior diameter is longer than anterior therefore a screw which appears to be just the right length on an anteroposterior X-ray, is too long and will penetrate the cortex and protrude deep to the MCL. The anterior surface slopes downwards to the medial side and corresponds in inclination to the patellofemoral joint.

When the distal femur is viewed from the side, the condyles appear to have been added posteriorly to the shaft. Therefore for the purpose of internal fixation, any device must be inserted into the middle of the anterior half of the condyles. The human femur is the longest bone in the human body and is capable of bearing loads of considerable magnitude.

When the structural integrity of the femur is compromised by a fracture of either high or low energy, it can pose a significant surgical challenge to treat. Not only these fractures are articular in nature – occurring in close proximity to the knee joint – but they are often very complicated breaks, resulting in many fragmented segments of bone that serve zero structural support to the femoral construct.

Mechanism of injury

Most distal femur fractures are a result of severe axial load with either varus, valgus , rotational or most frequently a combination of these forces[1,2]. In younger patients , high energy trauma is required to overcome the strength of the bone to produce a fracture , while in elderly patients, a minor slip and fall on a flexed knee is sufficient to generate the force required to produce these fractures. Once fractures occur, the deformities that occur are characteristic to these fractures[23,24].

Deformity	***Cause***
Femoral shortening, posterior displacement of distal fragment ,posterior angulation	Due to Quadriceps , hamstrings and gastrocnemius
Varus deformity	Due to Adductor muscle
Splaying and rotational malignment of condyles in intercondylar fractures	Due to separate attachment of gastrocnemius muscle to each condyle.

Diagnosis

The diagnosis of these fractures are relatively straight forward. The presence of pain and swelling & deformity in the thigh would immediately prompt an X ray evaluation , and the injury is rarely missed. But what needs to be ruled out is the presence of other injuries to the same limb and other parts of the body. It is not uncommon to miss a pelvic fracture or spine injury by devoting complete attention to distal femur fractures. A thorough assessment of the vascularity should be made as also examination of motor and sensory system. However , a neurovascular injury is relatively rare (<5%) inspite of close proximity of these structures to the fracture fragments.

INJURY PATTERNS IN DISTAL FEMORAL FRACTURS[29]

POLY TRAUMA	44%
CLOSED SOFT TISSUE INJURIES	20%
OPEN FRACTURES	24-40 %
INJURIES TO IPSILATERAL LIMB	17-27%
PATELLAR FRACTURES	4-19%
INJURIES TO CONTRALATERAL LIMB	10-13%
LIGAMENTOUS INJURIES	10-19%

Radiological Evaluation

Routine Xray evaluation includes Standard AP and Lateral views. Complex intra-articular fractures can be visualized better with 45^o oblique views. Gentle manual traction may be helpful in interpreting the fractures more clearly[23,24].

In complex lesions with shattered intraarticular fragments, CT scans may be helpful. In many centres, 3D reconstruction CTs are done routinely for intraarticular fractures to assist in pre-operative planning . Xrays of the ipsilateral hip, pelvis, and femoral shaft should be obtained to rule out associated injuries.

Arteriography is indicated in cases of diminished or absent pulse, expanding hematoma, persistent arterial bleeding through an open wound, injury to tibial nerve, or when there is clinical suspicion of knee dislocation.

Classification of Distal Femur Fractures

A good classification system for fractures of the distal femur should be able to clearly demarcate the different injury patterns prevalent in this region , should have good reliability , reproducibility and should be able to correlate with the prognosis for each injury pattern.

Many classification systems have been put forward of which the most popular one is the **OTA classification, developed by Muller because of its simplicity, reproducibility and wide acceptance among the orthopaedic surgeons.**

ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF DISTAL FEMORAL FRACTURES (OTA) DEVELOPED BY MULLER[23]

Type A :Extraarticular

A1: Simple (two part)

A2 :Metaphyseal wedge

A3 :Metaphyseal complex (comminuted)

Type B :Unicondylar, partial articular

B1 : Lateral condyle, sagittal

B2 : Medial condyle, sagittal

B3 : Frontal (coronal plane)

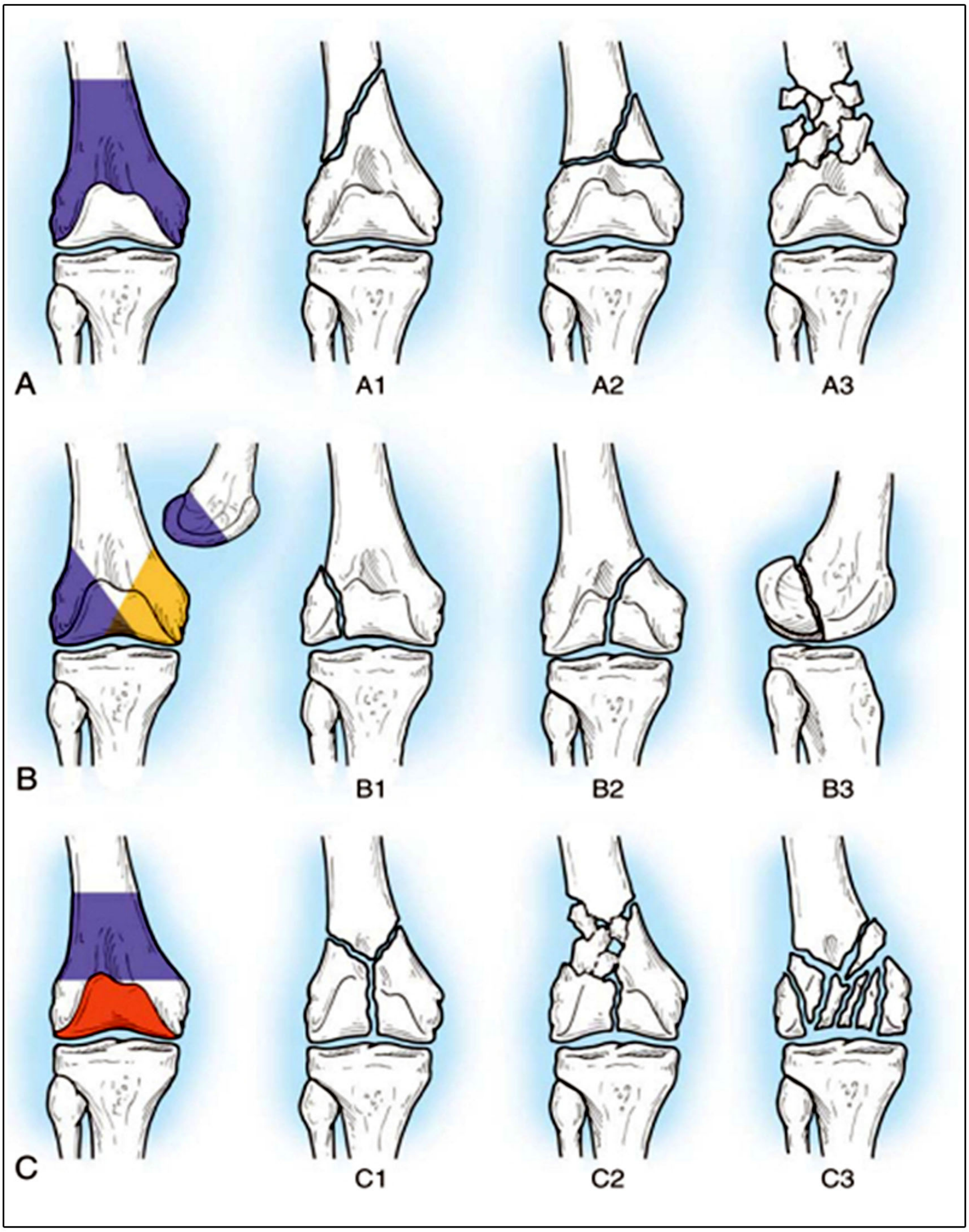
Type C :Intercondylar / bicondylar, complete articular

C1 : Articular simple, metaphyseal simple

C2 : Articular simple, metaphyseal complex

C3 :Multifragmentary articular fracture

ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION



NEER classified into 3 groups[1].

Group I : Minimum displacement, impacted, linear or slightlydisplaced, but stable after closed reduction.

Group II A : Condyles displaced medially, violent force applied to theanterolateral aspect of the flexed knee, oblique fractureextending from just proximal to the lateral epicondyle to wellabove the medial epicondyle.

Group II B : Condyles displaced laterally, severe force applied to thelateral side of the extended limb; the shaft is displacedmedially, and when the fracture is open, it penetrates the skinon the inner aspect of thigh, spares extensor tendon.

Group III : Conjoined supracondylar and shaft fractures, highenergy trauma to the anterior aspect of the flexed knee,when open, penetrates the skin superior to patella.

SEINSHEIMER CLASSIFICATION[2]

Type 1 : Nondisplaced fracture or those with less than 2 mm of displacement

Type 2 : Fractures involving the distal metaphysis only, without intraarticular extension

A. Two Part
B. Comminuted

Type 3 : Fractures involving the inter condylar notch in which one or both condyles are separate fragments

A. Medial Separate
B. Lateral Separate
C. Both Condyles Separated From The Shaft And From Each Other

Type 4 : Fractures extending through the articular surface of a femoral condyle

A) Through Medial Condyle (Two-Part Or Comminuted)
B) Through Lateral Condyle (Two Part Or Comminuted)
C) Complex And Comminuted

Treatment

Non Operative Treatment

Nonoperative treatment can consist of a long leg cast, followed by a hinged knee brace.

Indications

- Undisplaced fracture, with no ligament or meniscal injury
- Impacted stable fractures in elderly
- Select gunshot injuries
- Medically unfit

Contraindications

- Displacement of fracture
- Additional knee derangement

Advantages

- No surgery

Disadvantages

- Weakening of extensor mechanism
- Latent presentation of knee injury (anterior cruciate ligament)
- Knee stiffness secondary to immobilization
- Malunion / Nonunion

In stable , impacted fractures , immediate mobilization of the patient in a hinged knee brace , with restricted weight bearing can be undertaken. Careful X-ray follow up is required.

In unstable displaced fractures, 6-12 week period of skeletal traction followed by bracing can be undertaken. A Steinmann pin in proximal tibia with the limb supported on a Thomas splint with a Pearson knee attachment or on a Bohler Braun frame can be used. Alternatively, a two pin technique , with a further pin in the distal femur is used in difficult to reduce cases.

Operative treatment[23,24]

Indications

- Displaced fractures
- Displacement of fracture with knee movement
- Young active patient
- Associated derangement of the knee
- Periprosthetic fractures
- Marked Obesity
- Pathological fractures

Contraindications

- Patient unfit for surgery

Advantages

- Early patient mobilization
- Allows for examination under anesthesia of the knee

Disadvantages

- Surgical scarring
- Risk of infection

Provisional treatment

In some cases, a period of non-operative treatment may be necessary before the patient’s general condition, or the status of the adjacent soft-tissues, will permit safe surgery. In these instances, temporary splintage, or external fixation, can be used.

Surgical Goals

The aims of operative treatment are:

- Anatomical reconstruction of the articular surfaces,
- Restoration of rotational and axial alignment,
- Stable fixation of the condyles to the shaft of the femur,
- Early functional aftercare.

Treatment Options[30]

Screw fixation

Large and small screws, solid or cannulated, can be used for the reconstruction of the articular block at the condyles. Except for type B fractures, the stability of the fixation must be increased by a plate with buttress function .In type B fractures it may be possible to insert the screws through small stab incisions or under arthroscopic control; for reconstruction of complex intra-articular fractures a formal arthrotomy is usually required.

Condylar plate/dynamic condylar screw (DCS)

In the treatment of complex extra-articular fractures (33-A) fractures, and simple intra-articular fractures (type C1.2) the classical implants, the condylar plate 95^{o}, and the DCS have proven to be reliable and effective.

The DCS is somewhat less demanding than the condylar plate and can be implanted with minimal soft-tissue exposure. After reduction of the articular fragments, the condylar screw is inserted over a correctly placed guide pin under fluoroscopic control. The side plate can then be slid underneath the vastus lateralis muscle along the linea aspera of the femur. With the impactor the side plate is seated against the shaft of the bone and then locked to the condylar screw. To fix the plate to the femur, a short incision has to be made at its proximal end. It is possible, but more demanding, to insert the condylar plate in a similar fashion using longer incisions and reflecting the vastus lateralis. After the implant is inserted with the blade parallel to the joint line, it is fixed to the distal femur, maintaining correct frontal and sagittal alignment. Additional stability of the blade can be achieved if cancellous bone screws are inserted through the plate into the condyles .

Retrograde nailing

Retrograde nailing is suitable for extra-articular (33-A) and sometimes also for simple articular fractures (33-C1, 33-C2) . Under fluoroscopic guidance, with the knee flexed, a medial parapatellar arthrotomy is used to gain transarticular access. The medullary canal is opened just anterior to the notch (caveat cruciate ligament origin), and the slightly bent solid distal femoral nail (DFN) is inserted into the medullary cavity with the mounted aiming device. Due to its axial and bending stability, the locked intramedullary nail, unlike the blade plate or DCS, provides adequate long-term stability without additional bone grafting, even in multifragmentary supracondylar fractures

External fixation

The indications for temporary joint bridging external fixation are polytrauma patients, open fractures, or closed fractures with severe soft tissue damage. If possible, the articular block is reconstructed with minimal internal fixation using conventional or cannulated lag screws. Then the joint bridging external fixator is mounted with Schanz screws, which are inserted laterally in the femur and anteromedially in the tibia. Both elements are then connected in a tube-to-tube fashion, thus providing sufficient stability until definitive treatment is feasible.

Locking Compression Plates[10,17,18,20,23,24,29]

History of Internal Fixators

1) The Zespol system was developed in Poland in 1970's.

2) The "Schuli" device designed by Jeffrey Mast consisted of standard internal fixation plate with screw held in position using washer on the side of the plate facing the bone.

3) The PC- Fix was developed in a joint venture by AO research institute and AO development institute – key features being tapered screw ensuring angular stability and monocortically inserted screw.

4) To provide axial anchorage of the screw to the plate, the locking head screw was developed.

Angular stable implants especially non-contact plates are called Locked Internal Fixators. Stability is not achieved by friction between the plate and the bone but by connecting the extramedullary load carrier and the main fragments of the bone.

The locking head screw is subjected to mainly bending and shearing forces that occur at the neck of the screw. The screw design had to be adapted to the new mechanical conditions. Thus the locking head screw is a more symmetrical thread with a coarser thread pitch, with more outer and core diameter. This modification increases projection area by 40% permitting distribution of forces to larger bone. And due to larger core diameter, the screw tolerates 100% more shearing stress and 200% more bending stress thus reducing the incidence of screw failure.

Another modification relates to the absence of axial preload in the application of locking head screw. Harmful micro movements which are prevented by the axial preload can be countered in the locking screw by the press-fit technique.

In plate – screw configuration with non-locking screws, conventional screws are stand alone screws allowing gradual loosening with pullout of individual screws. In case of fixed angle application, the Locking Head Screw can no longer be regarded as a stand alone screw and the fixed angle connection between the plate and the screw head prevents screw orientation along the axis of force. Pull out can only occur en-bloc.

Advantages of Locking Head Screws

1) Provide better anchorage both in elastic bridging fixation and in absolutely stable fixation, thus offering important advantages in the treatment of fractures in osteoporotic bone.

2) Allows dependable application of monocortical screws in region of the diaphysis.

3) Blood supply to the periosteum[25] is preserved.

4) No structural bone loss of the opposite cortex .

5) Easier to apply monocortical screws in blind minimally invasive percutaneous osteosysthesis.

6) Bicortical cortical screws offer improved stability in epiphyseal and metaphyseal regions of the bone.

7) They provide fixed angle device, preventing varus collapse, toggle and sequential screw loosening particularly in osteoporotic bone[13].

Disadvantages

1) Current locking plate design maintains fracture reduction but does not obtain it.

2) The surgeon has no tactile feedback as to the quality of bone, when tightening the screws because the screws stop abruptly when threads are completely seated into the plate regardless of bone quality.

3) Locked screws on its own will not pull the plate down to bone; hence this lack of construct reduction capability, combined with percutaneous plating techniques, can result in higher rates of fracture malalignment than that occur with formal open reduction and internal fixation.

4) Another concern is the rigidity of a locked screw plate construct. Any fracture distraction at the time of reduction or fracture resorption during healing will be held rigidly by such constructs which prevent bone to bone contact and may potentially result in delayed union or non union.

5) No load sharing can occur with locked screws on either side of a fracture.If the fracture is repetitively loaded, the plate eventually may fracture or fixation may be lost.

6) Some locking plate designs,do not allow the angling of the screws by the surgeon within the hole and still achieve a locked screw.

7) Contouring locked plates distort the screw holes and adversely affect the screw purchase.

8) Hardware removal may be more difficult, if locked screw become cold welded to the plate.

Aim of Reduction

In diaphyseal and metaphyseal bone, the aim should be to restore the correct alignment of the epiphyses. In articular fractures, anatomical reduction of joint surfaces with elevation of impacted areas is mandatory to prevent post traumatic osteoarthritis.

Reduction Instruments

1) Traction tables

2) Small reduction tables

3) Distractor

4) External Fixator

5) Pointed Reduction forceps(Weber Forceps)

6) Reduction forceps , Serrated jaws

7) Bone Spreader (for Push Pull technique)

8) Collinear reduction clamps

9) King tong and Queen tong forceps(Reduction forceps with pointed ball tip)

Features of Anatomically precontoured low profile plates

– Reduced soft tissue problems

– No need for plate contouring

Features of LCP combi-holes

It combines a dynamic compression unit (DCU) hole with a locking screw hole thus permitting an internal plate fixation using standard screws, locking screws or a combination of the two.

Angular stability

- Prevents screw loosening as well as primary and secondary loss of reduction
- Allows early functional mobilization
- As an internal fixator the plate preserves bone vascularization
- Offers improved purchase in osteoporotic bone

Indications of Distal Femur – LCP

1) Supracondylar fractures

2) Articular fractures

3) Distal shaft fractures

4) Periprosthetic fractures

5) Repeated fracture with implants in place

6) Fractures in osteoporotic bone

7) Pathological fractures

MATERIALS AND METHODS

Study Topic	**:**	**Study of functional outcome of 20 cases of displaced Distal Femur fractures fixed with distal femur Locking Compression Plate**
Study Design	**:**	Prospective study
Study Venue	**:**	Department of Orthopaedics, Government Mohan Kumaramangalam Medical college and Hospital, Salem-1.
Period of Study	**:**	May 2010 to November 2012
Sample size	**:**	Twenty patients

Inclusion criteria:

1) Presence of distal 3rd femoral fractures which needs to be internally fixed in displaced Muller's type A and Type C fractures.

2) Age more than 16 years.

3) Patient who is preoperatively mobile.

Exclusion criteria:

1) **S**keletal immaturity with open physis.

2) Muller's type B fracture.

3) Undisplaced fracture patterns needing only Conservative management.

4) Patients not willing for surgery.

5) Pathological fractures.

6) Periprosthetic fractures.

PRE OPERATIVE PROTOCOL

Examination

A thorough clinical examination was done as per predesigned and pretested proforma which included age, sex, occupation, mode of injury, type of fracture, time interval between injury and surgery, associated comorbid conditions and other associated injuries.

Investigations

Routine investigations like Haemogram, Blood sugar, Urea, Creatinine, Serum electrolytes, X- ray Chest , ECG, BT, CT was done. Medical and anaesthetic fitness was obtained for all the patients before surgery.

X-Rays

X-ray Femur AP / Lateral view from the knee to proximal femur was taken for all the20 cases and following features were assessed : Type of fracture, Amount of Comminution, Articular congruence and Quality of bone . All other requisite Xrays to rule out associated injuries were also taken.

Step –by- step surgical sequence for Distal Femur LCP fixation

Preoperative Selection of Implants

The preoperative x-ray is used to determine the length of the LCP and the position of the screws. To measure the length of the condylar screw, the Maximum condylar width on the radiograph is determined to determine the real condylar width.

Patient Position

Patient is positioned in supine position with a sandbag under the ipsilateral buttock to internally rotate the leg for easier approachability. A radioluscent table is used to facilitate the use of Image Intensifier during the procedure for visualization of articular congruence. A sterile bolster is placed under the knee to counter the hyperextension deformity of the femoral condyles during reduction.

Surgical Approach - Lateral/anterolateral approach to the distal femur

General considerations

This approach to the distal femur allows for visualization, reduction and fixation of simple articular fractures of the distal femur. It relies on an atraumatic elevation of the vastuslateralis from the lateral aspect of the distal femur, and a lateral arthrotomy for joint visualization. Articular reduction and plate application can both be achieved with the approach. The approach can also be extended proximally, as described in the lateral approach to the femoral shaft . It can be used without an arthrotomy if the articular surface is not fractured (A-type fractures).

Prophylactic antibiotics

We used gram-positive prophylactic antibiotic cover for closed fractures, adding gram-negative prophylactic cover for open fractures. However, antibiotic therapy would not compensate for poor surgical technique.

Skin incision

The skin incision is made in the mid-lateral line of the femoral shaft and curved anteriorly over the lateral femoral condyle, towards the tibial tubercle. The proximal point for the skin incision depends on the most proximal extent of the fracture. If joint visualization is necessary, the incision is carried to the level of the tibialtubercle . If an arthrotomy is not required, the skin incision can be stopped approximately 1-2 cm distal to the joint line.

Division of the iliotibial band

The iliotibial band (tract) is divided in line with the skin incision. Distally, the fibers curve anteriorly towards the tibial tubercle. The incision through the iliotibial band should follow this fiber orientation.

Elevation of vastus lateralis

The fibers of the vastus lateralis are minimal in the distal 8-10 cm of the femur. The muscle fascia investing the vastus lateralis is incised just anterior to the lateral intermuscular septum and the muscle fibers are elevated off the septum, working from distal to proximal most easily accomplished by use of a large elevator. The vastus lateralis is retracted anteromedially. Several perforating vessels of the profunda femoris artery and vein have to be ligated.

Joint capsule arthrotomy for articular surface visualization

For cases in which the articular surface needs to be exposed (B- or C-type fractures), a joint capsule arthrotomy is performed. The joint capsule is incised over the anterior third of the lateral femoral condyle. This joint arthrotomy can be carried distally as far as the lateral meniscus.

To facilitate exposure of the articular surface, a blunt angled retractor can be used. Care has to be taken to avoid excessive tension on the patellar tendon, especially in osteoporotic individuals.

In three cases of C3 Type of Distal femur fractures, we used Swashbuckler Approach to obtain proper visualization of entire joint surface.

Swashbuckler Approach

A midline incision was made from above the fracture laterally to across the patella.The incision was extended directly down to the fascia of the quadriceps. The quadriceps fascia was incised in line with the skin incision and sharply dissected off the vastus lateralis muscle laterally to its inclusion with the iliotibial band. The iliotibial band and fascia was retracted laterally, and the dissection was continued down to the linea aspera. The lateral parapatellar retinaculum was incised, separating it from the vastus lateralis. A lateral parapatellar arthrotomy was made to expose the femoral condyles. A retractor was placed under the vastus lateralis and medialis which were retracted medially, exposing the distal femur and displacing the patella medially. The perforating vessels were ligated, and the vastus lateralis was elevated, exposing the entire distal femur.

Provisional Fracture Fixation

Manual traction is applied, the supracondylar towel rolls are put in place, and the fracture reduction is visualized on both AP and Lateral views .The above mentioned reduction instruments can be used to achieve reduction which can be confirmed under fluoroscopy. Indirect reduction of the condyles was done using point reduction clamp and image intensifier. In case of articular fractures, attempt at perfect articular surface congruence was done. The reduction was held temporarily using two K wires thus converting the condylar fragments into one fragment. The K wires were placed so that subsequent plate positioning is not hindered.

LCP Insertion

The DF-LCP is then inserted either through the anterolateral or the lateral parapatellar approach. The implant is precontoured to accommodate the anterior curve of the femur. A common tendency is to direct the fixator posteriorly due to its weight. The fixation bolt has to be oriented parallel to the patellofemoral joint and it has to lie flat up against the lateral surface of the condyle to ensure optimal fitting on the bone.

The LCP usually lies approximately 1.0 – 1.5 cm posterior to the most anterior aspect of the distal femoral condyle and approximately 1.0 – 1.5 cm cranial to the distal femoral condyle.

The condyles were fixed to the plate using 6.5mm cannulated locking head cancellous screws without disturbing the reduction. The reduction and the position of the plate were controlled clinically and with fluoroscopy assisstance.

The condylar fragment was then aligned with the metaphyseal fragment by appropriate manipulation (traction and rotation) under fluoroscopy. The reduction was held temporarily with K wires, after aligning the plate along the shaft. The plate was then fixed to the shaft with either the ordinary cortical screw or the locking head screw in the combi holes.

Intraoperative Assessment of Fracture Reduction

The knee is taken through full range of gentle motion to ensure appropriate fracture fixation. Specific questions asked in this assessment are:

1. How satisfactory is the varus / valgus alignment?

2. Is there hyperextension of the distal femoral condyles?

3. How is the length , alignment , and rotation clinically?
4. How satisfactory is the placement of the implant on the midlateral aspect of the femoral shaft?
5. How satisfactory is the placement of the implant on the lateral aspect of the distal femoral condyle?
6. Are any of the screws placed too far anteriorly or posteriorly?
7. Are any of the distal Locking screws in the patellar groove or intercondylar notch?
8. It should be checked that self-drilling , self-tapping locking screws have not perforated the medial cortex.

Wound closure

The joint capsule arthrotomy, fascia of the vastus lateralis and the iliotibial band are closed with absorbable sutures. The skin and subcutaneous tissues are closed in a routine manner. The use of suction drains may be considered.

Post Operative Care And Rehabilitation

Proper rehabilitation is essential to attain a satisfactory range of motion, strength and function of the knee. Rehabilitation should be tailor made for each patient according to the stability of fixation. If fixation is stable, then therapy can be started early. The most useful range of motion can be achieved in the first 2 months of postoperative period.

Early Phase (1-3 Weeks)

Range of motion exercises are started on 2nd day as tolerated by the patient. Quadriceps strengthening and hamstring stretching exercises are encouraged.

Role of Continuous passive motion when started in 1st week

1) Increases early range of motion of knee.
2) Decreases incidence of DVT and pulmonary embolus.
3) Faster pain relief and hence shorter stay at hospital.
4) Better results when used at a rate of 1 cycle per minute, with 40 degrees of maximum flexion for first 3 days.

Continuous passive motion improves cartilage nourishment, reverses collagen loss, and prevents joint stiffness.

Non – weight bearing with crutches or walker support can be initiated in 1st week, if fixation is stable.

Late Phase (After 3weeks)

- Isometric quadriceps exercises, Active and passive Range motion exercises are continued.
- Seated knee extension exercise.
- Partial weight bearing is allowed after 6^{th} week.
- Full weight bearing is allowed after radiological evidence of healing.

GOALS OF REHABILITATION

- About 65° - 70° flexion is required during the swing phase of normal gait.
- About 90° flexion is required to ascend and descend stairs.
- About 105º flexion is required to rise early from a low chair and to tie one's shoes. To achieve this, CPM was recommended for 3 hours daily for 2-3 weeks, till the patient achieves more than 100º flexion.

OBSERVATIONS

Table 1: Sex distribution of the patients

SEX	Total Number	%
Male	12	60
Female	8	40

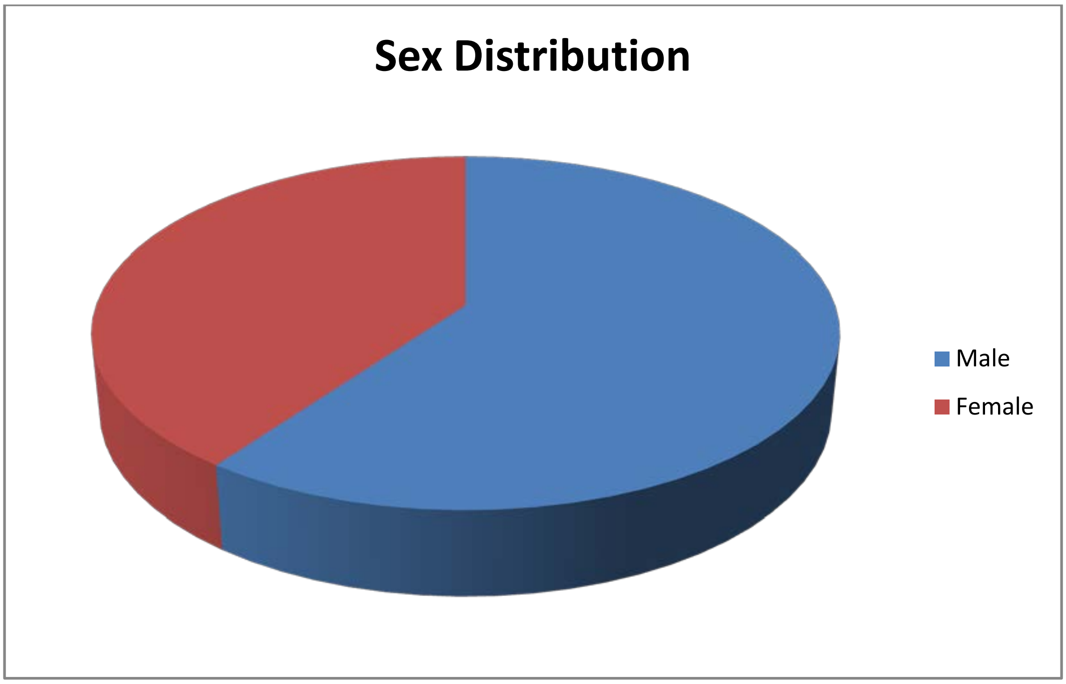


Table 2: Age of the patients

Age	*No. of patients*	*Percentage*
20-30yrs	1	5
30-40yrs	5	25
40-50yrs	4	20
50-60yrs	2	10
60-70yrs	7	35
70-80yrs	0	0
80-90yrs	1	5

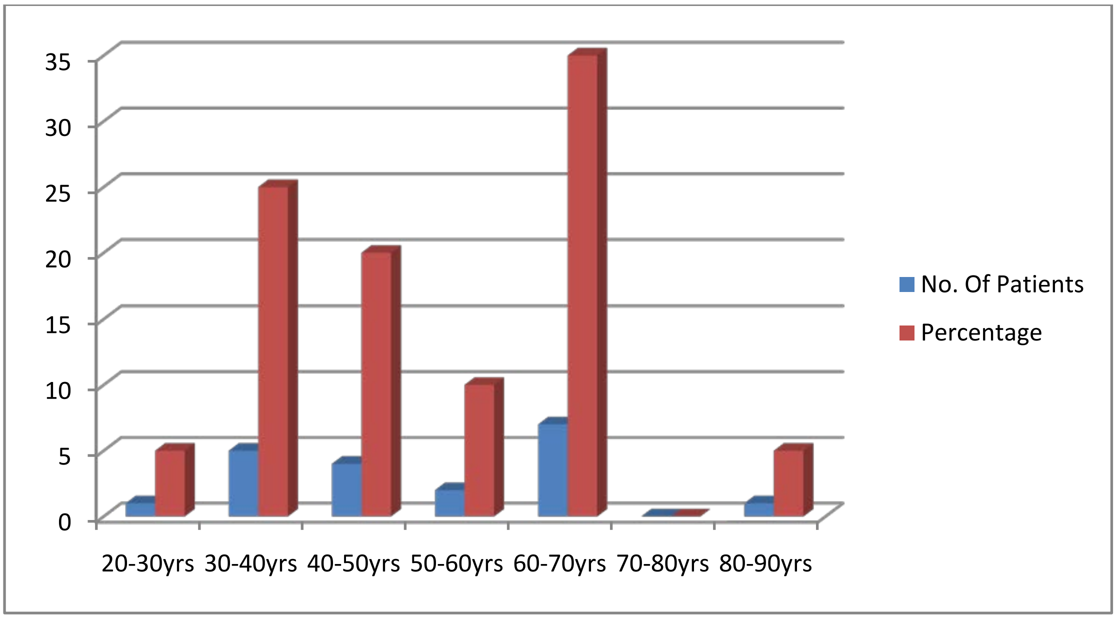


Table 3: Side of the affected limb

Side	*No. of patients*	*Percentage*
Right	16	80
Left	4	20

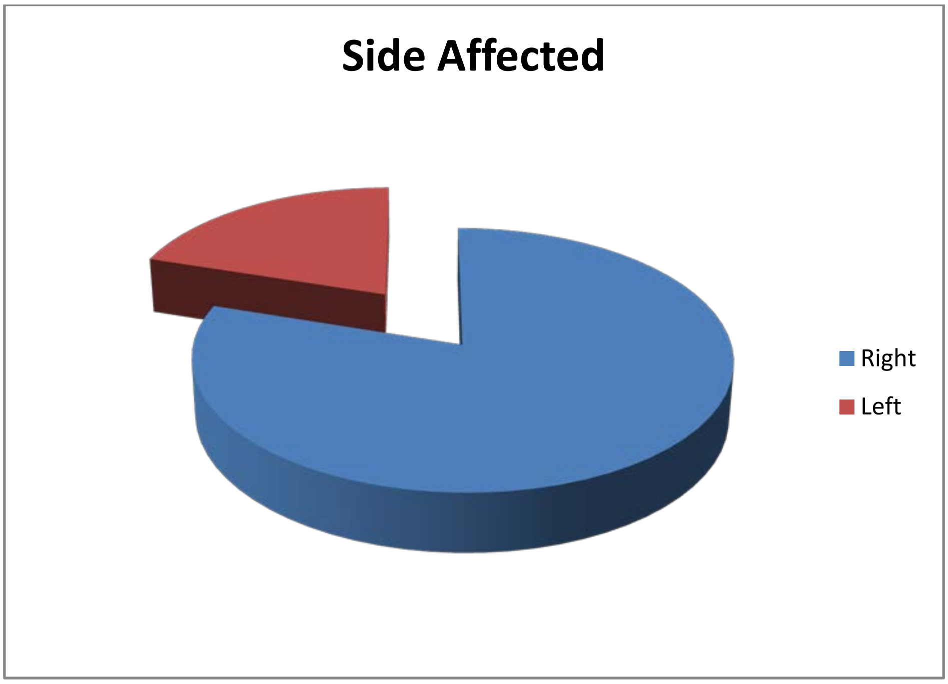


Table 4: Associated comorbid conditions

Comorbid conditions	No. Of Patients
Hypertension	6
Diabetes	3
Others(IHD/COPD)	5

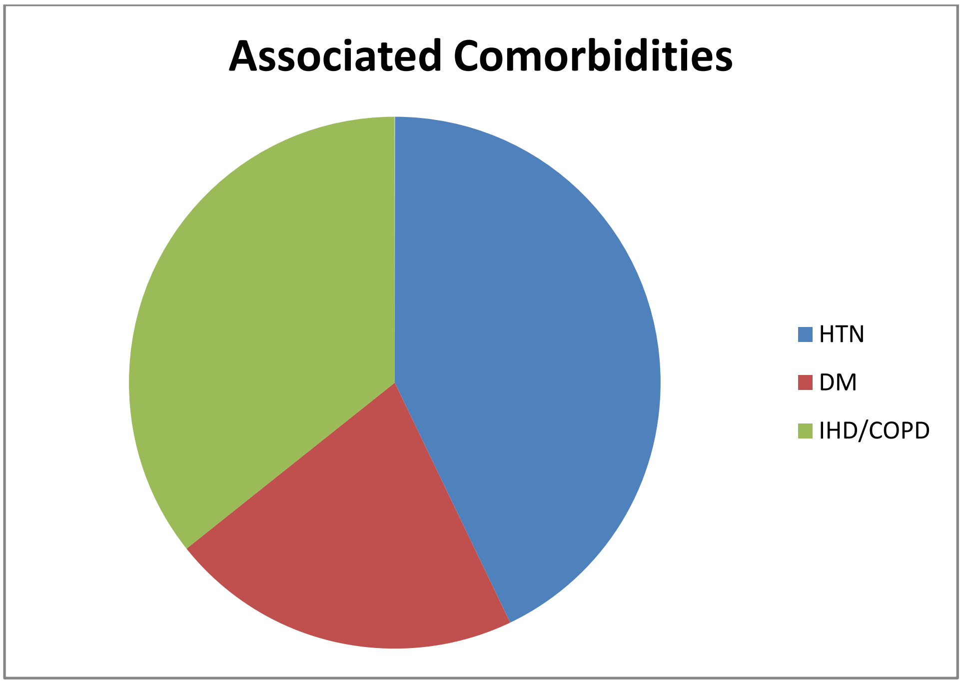


Table 5: Mode of injury

Mode of Injury	No. of Patients	Percentage
RTA	15	75
ACCIDENTAL FALL	5	25

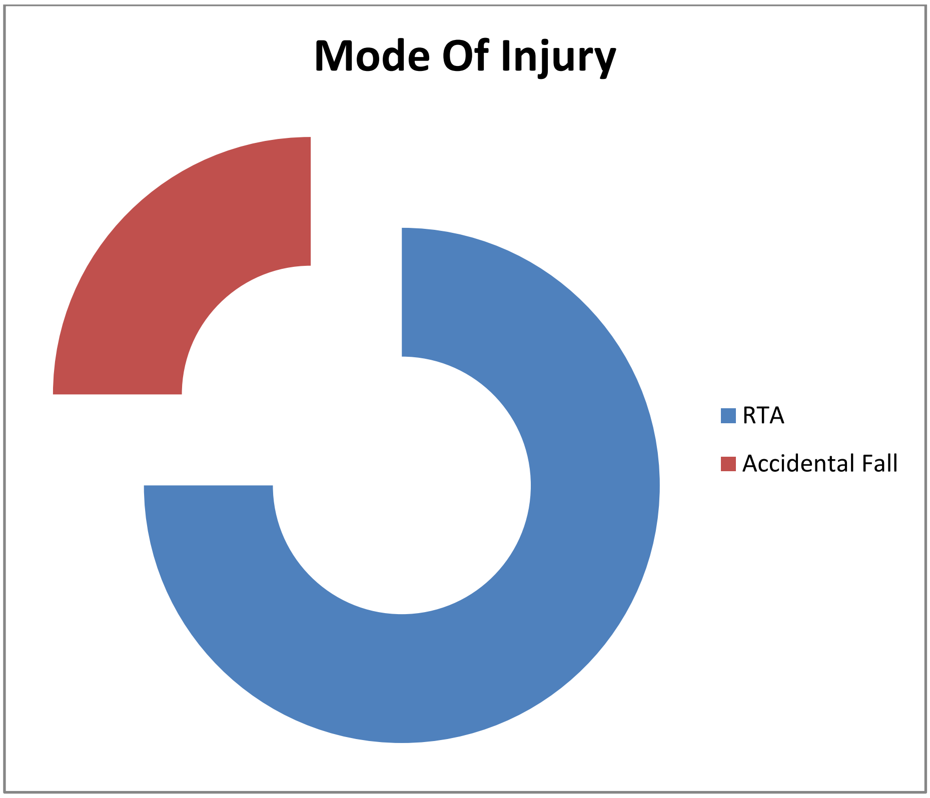


Table 6: Closed vs Open fractures

Type of Fracture	No. Of Patients	Percentage
Closed	18	90
Open	2	10

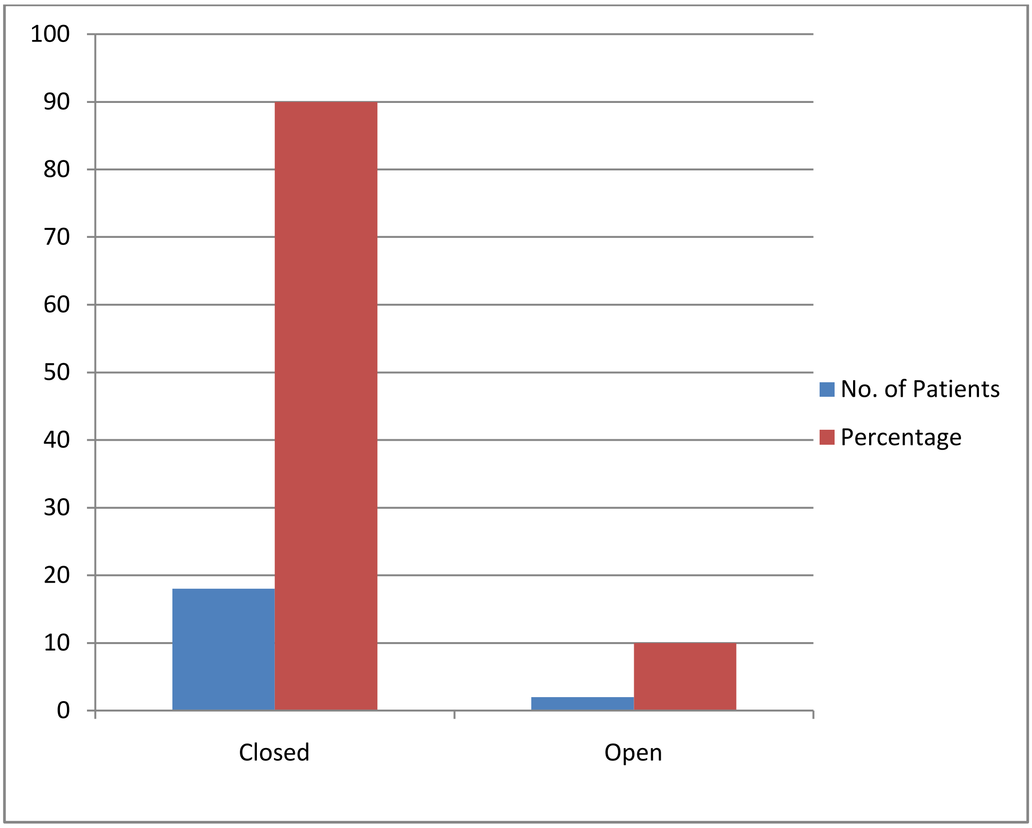


Table 7 : Occupational distribution

SNo.	Occupation	No. Of Patients
1.	Labourer	5
2.	House wife	8
3.	Skilled Labourer	3
4.	Business	1
5.	Professional	3

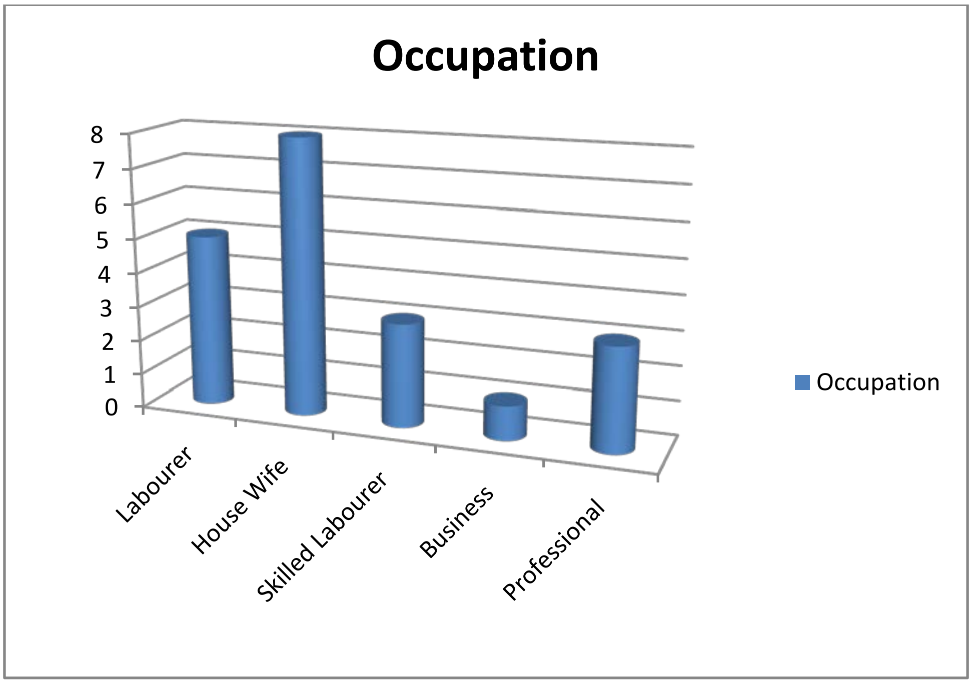


Table 8 : Associated Injuries

SNo.	Associated Injuries	No. Of Patients
1.	Tibial Condyle fractures	1
2.	Tibial shaft fractures	4
3.	Talus fractures	1
4.	Contralateral Both bone leg fractures	2
5.	Head Injury	1

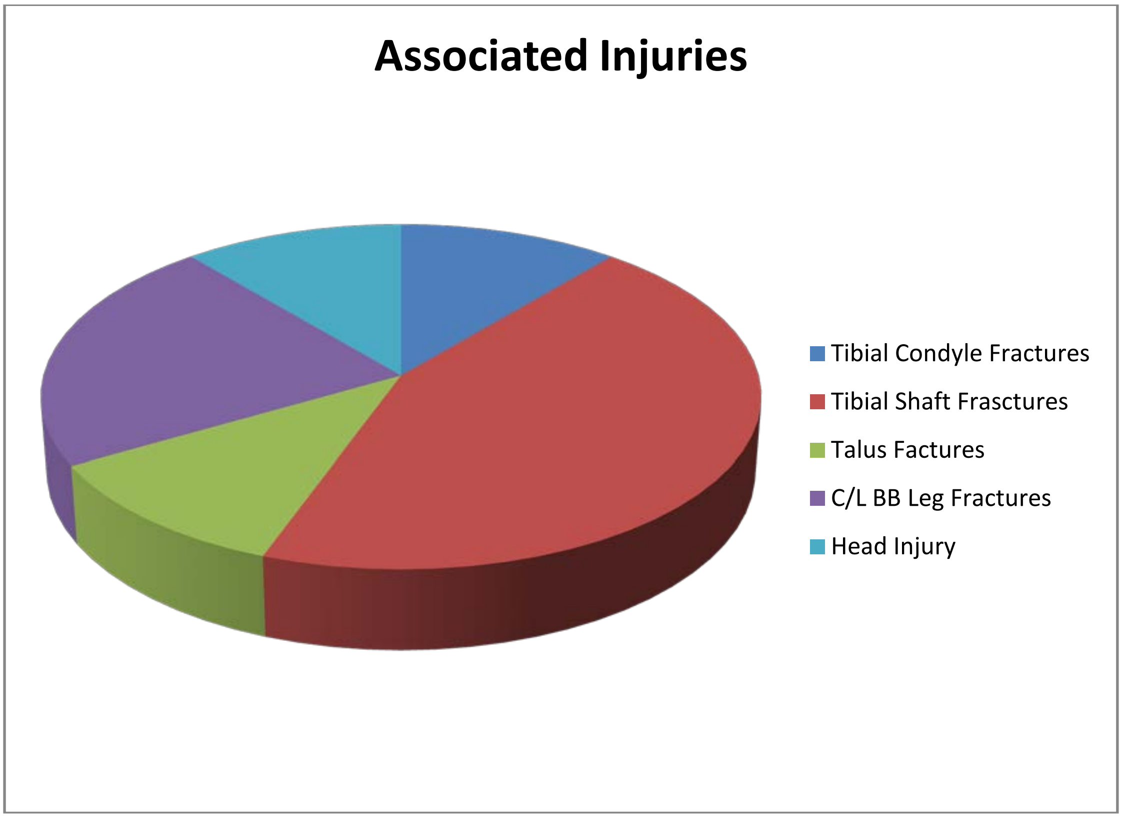
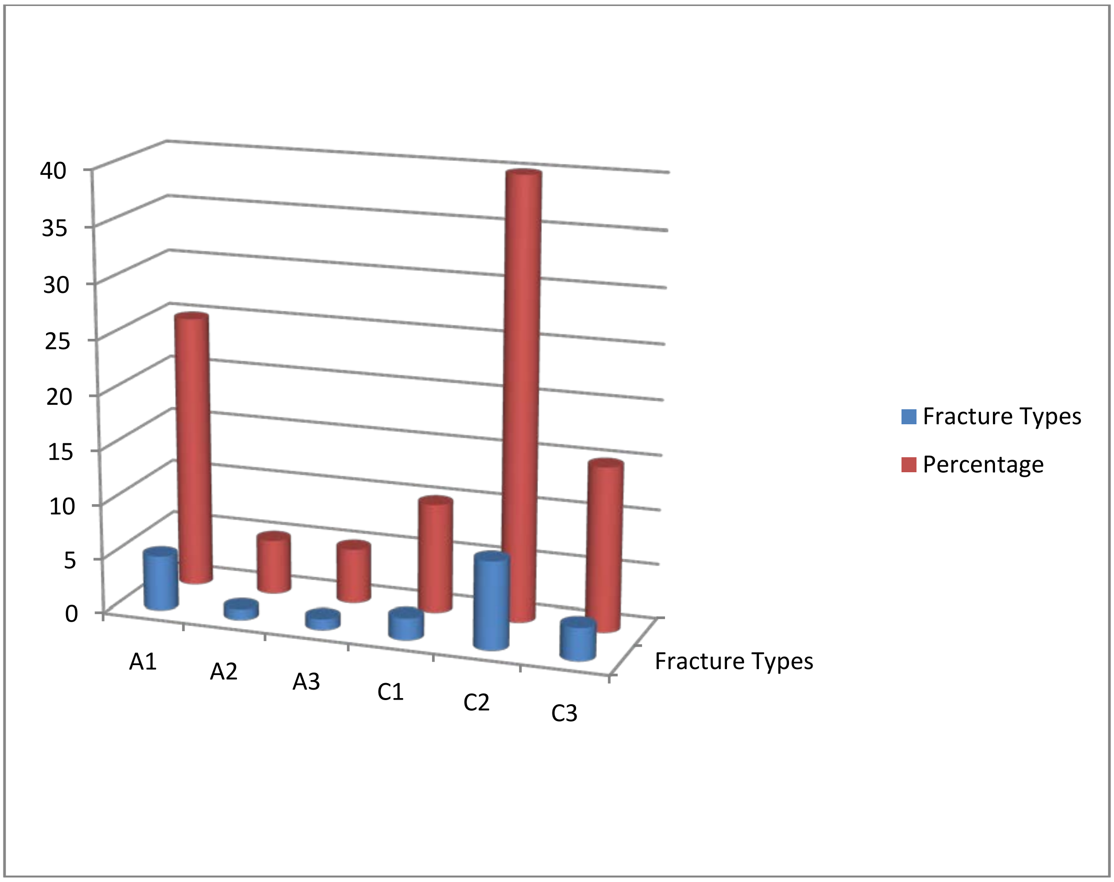


Table 9: Fracture Classification

SNo.	Fracture Classification(OTA)	No. of Patients
1.	A1	5
2.	A2	1
3.	A3	1
4.	C1	2
5.	C2	8
6.	C3	3



Case Illustrations

Case I

Name	**: Kaliraman**
Age/Sex	**: 43/Male**
Mode of Injury	**: RTA**
Side	**: Right**
Associated Injury	**: None**
Associated Comorbidity	**: None**
Muller's Type	**: Closed Type C2 Fracture**
Time Interval for Surgery	**: 7 days**
Time for Radiological Union	**: 11 weeks**
Knee Flexion Achieved	**: 130 ^{o}**
Functional Outcome	**: Excellent**

CASE - 1


PRE OP AP X-RAY


PRE OP LATERAL X-RAY

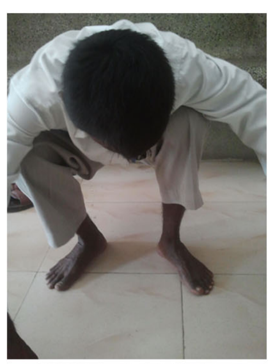

POST OP AP X-RAY


POST OP LATERAL X-RAY


6 MONTHS FOLLOW UP


6 MONTHS FOLLOW UP


KNEE EXTENSION


KNEE FLEXION


CROSS LEG SITTING

Case II

Name	**: Perumayee**
Age/Sex	**: 87/Female**
Mode of Injury	**: Accidental Fall**
Side	**: Right**
Associated Injury	**: None**
Associated Comorbidity	**: Hypertension**
Muller's Type	**: Closed Type C2 Fracture**
Time Interval for Surgery	**: 9 days**
Time for Radiological Union	**: 15 weeks**
Knee Flexion Achieved	**: 100^{o}**
Functional Outcome	**: Excellent**

CASE - 2


PRE OP AP X-RAY


PRE OP LATERAL X-RAY


POST OP AP X-RAY


POST OP LATERAL X-RAY


6 MONTHS POST OP


6 MONTHS POST OP


KNEE FLEXION


KNEE EXTENSION

Case III

Name	**: Subramani**
Age/Sex	**: 55/Male**
Mode of Injury	**: RTA**
Side	**: Right**
Associated Injury	**: Fracture Proximal Tibial Shaft**
Associated Comorbidity	**: Ischaemic Heart Disease**
Muller's Type	**: Closed Type C2 Fracture**
Time Interval for Surgery	**: 9 days**
Time for Radiological Union	**: 14 weeks**
Knee Flexion Achieved	**: 120^{o}**
Functional Outcome	**: Excellent**

CASE - 3


PRE OP AP X-RAY

PRE OP LAT X-RAY


POST OP AP X-RAY


6 MONTHS POST OP


6 MONTHS POST OP


KNEE FLEXION


KNEE EXTENSION

Case IV

Name	**: Ravikumar**
Age/Sex	**: 34/Male**
Mode of Injury	**: RTA**
Side	**: Right**
Associated Injury	**: Fracture Both Bone Right leg**
Associated Comorbidity	**: None**
Muller's Type	**: Closed Type A3 Fracture**
Time Interval for Surgery	**: 5 days**
Time for Radiological Union	**: 14 weeks**
Knee Flexion Achieved	**: 100^o**
Functional Outcome	**: Good**

CASE - 4

PRE OP AP X-RAY

PRE OP LATERAL X-RAY

POST OP AP X-RAY

POST OP LATERAL X-RAY

6 MONTHS POST OP

6 MONTHS POST OP

KNEE FLEXION

KNEE EXTENSION

Case V

Name	**: Thangaraj**
Age/Sex	**: 27/Male**
Mode of Injury	**: RTA**
Side	**: Right**
Associated Injury	**: Head Injury**
Associated Comorbidity	**: None**
Muller's Type	**: Grade IIIA Type C2 Fracture**
Time Interval for Surgery	**: 7 days**
Time for Radiological Union	**: 15 weeks**
Knee Flexion Achieved	**: 40^{o}**
Functional Outcome	**: Poor**

CASE - 5

PRE OP X-RAY

POST OP X-RAY

WOUND INFECTION

6 MONTHS POST OP

KNEE STIFFNESS

PERSISTENT STIFFNESS AFTER 1YEAR

RESULTS

NEER'S FUNCTIONAL SCORING was used to assess the outcome of surgery for adult distal femoral fractures. It consists of :

Functional (70 units) and Anatomic (30 units)

Table I

Pain (20 units)	Unit Value
5- No pain	20
4- Intermittent	16
3-With fatigue	12
2-Restrict function	8
1-Constant or night pain	4

Table II

Function (20 units)	Unit Value
5- As before injury	20
4- Mild Restriction	16
3-Restricted	12
2- Cane or severe restriction	8
1-Crutches or brace	4

Table III

Motion(20 units) Knee Flexion	Unit Value
5- Normal or135 degrees	20
4-100 degrees	16
3- 80 degrees	12
2- 60 degrees	8
1- 40 degrees	4
0- 20 degrees or less	0

Table IV

Work (20 Units)	**Unit Value**
5-As before injury	10
4- Regular but with handicap	8
3-Alter work	6
2-Light work	4
1-No work	2

Table V

Gross Anatomy(15 units)	**Unit value**
5-Thickening only	15
4- 5^{o}angulation or 0.5cm short	12
3-10^{o}angulation or rotation,2cm short	9
2-15^{o}angulation or rotation,3cm short	6
1-Union but with greater deformity	3
0-Nonunion or chronic infection	0

Table VI

Roentgenogram(15units)	Unit value
5-Near normal	15
4- 5^{o}angulation or 0.5cm displacement	12
3-10^{o}angulation or rotation,1cm displacement	9
2-15^{o}angulation or rotation,2cm displacement	6
1-Union but with greater deformity, spreading of condyles, osteoarthritis	3
0-Nonunion	0

.

Table VII

Outcome	Score
Excellent	Above 85 Units
Good	70-85 units
Fair	55-69 units
Poor	Below 55 units

Overall results were excellent in 11 out of 20 cases and were good to fair in 7cases.The outcome was poor in 2 cases. The overall mean score in our study was 76.6 units.

Overall Results

Grading	No. of Cases	Percentage
Excellent	11	55
Good	5	25
Fair	2	10
Poor	2	10

Results according to Individual Criterias

Character	**Score**	**No. of Patients**
Pain	20	8
	16	7
	12	3
	8	2
	4	-
Function	20	12
	16	2
	12	3
	8	3
	4	-
Motion	20	10
	16	4
	12	3
	8	1
	4	2
	0	-

Work	10	2
	8	4
	6	11
	4	2
	2	1
Gross Anatomy	15	6
	12	10
	9	3
	6	1
	3	-
	0	-
Roentgenogram	15	1
	12	12
	9	6
	6	-
	3	1
	0	-

Results According to Subtype

Mullers Subtype	**Excellent**	**Good**	**Fair**	**Poor**
A1	2	1	2	-
A2	1	-	-	-
A3	-	1	-	-
C1	2	-	-	-
C2	4	2	-	2
C3	2	1	-	-

COMPLICATIONS

The following complications may be expected during the treatment of these fractures.

Early

1. Iatrogenic fractures , especially in osteoporotic bones.
2. Damage to medial and lateral collateral ligaments of knee and menisci.
3. Damage to popliteal vessels, though very rare.
4. Damage to geniculate vessels and accompanying nerves.

Late

1. Infection
2. Loss of Reduction, due to improper surgical technique or poor bone
3. Stock or poor patient compliance
4. Nonunion, Malunion in varus. Valgus and varusmalalignment more than 10° and / or rotational deformity more than 15°, should be corrected.

5. Knee stiffness

6. Secondary osteoarthritis if articular incongruity is present

Of all the early complications, we encountered the rather rare complication of popliteal artery injury in one of our early patients. A 65 year old woman had an accidental fall and sustained A1 type of fracture which was immobilized with Above Knee slab. Due to her comorbidities, she could be operated only 3 weeks after her injury. Her intraoperative period was uneventful and Locking compression plate was implanted. During the immediate post-operative period, her distal pulse was absent. A Doppler study of Left lower limb was done which showed long segment occlusive thrombus in popliteal artery extending into distal one third of superficial femoral artery and absent flow signal in proximal $2/3^{rd}$ of anterior tibial artery and 20% flow in distal $1/3^{rd}$ of anterior tibial artery. Patient was immediately heparinised and kept in observation. She slowly regained her vascularity and no further intervention had to be done. Though she could get only 50^{o} of knee movement, she had delayed union at 19 weeks. In this case, as she was immobilized in a slab for 3 weeks, we attributed the vascular injury to manipulation in the intraoperative period causing thrombosis of popliteal artery due to the resistant fibrous tissue around the fracture site. All subsequent cases were put on skeletal traction and this complication did not recur.

Deep infection occurred in only one case, which was a compound fracture and it was treated with parenteral antibiotic after identifying the organism. Patient had delayed union and functional outcome was poor.

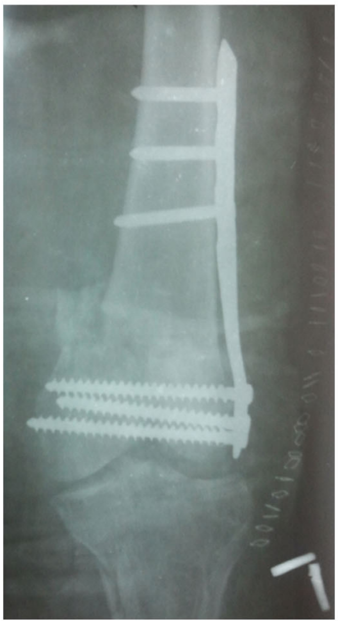
Apart from the above 2 patients, knee stiffness occurred in one other patient due to noncompliance with physiotherapy.

Malunion occurred in two elderly female patients but since their functional outcome was good, it was not addressed.

In one patient, there was screw penetration into the joint space. She could obtain $100^{o}$of knee flexion and had a good overall outcome.

COMPLICATIONS

VARUS MALUNION



SCREW PENETRATION INTO KNEE JOINT

WOUND INFECTION

KNEE STIFFNESS

DISCUSSION

The evolution of treatment of distal femur fractures has come a long way in modern orthopaedics from totally conservative treatment in the 1960's to essentially surgical treatment in the present. The comminuted type of distal femur fracture are increasingly being encountered due to the prevalence of speedy vehicles and the high two wheeler population in countries like India. Also improved healthcare results in a longer lifespan and hence we see more and more patients with osteoporotic fractures which were previously treated using conservative methods. There is also great expectancy on the part of the patient regarding outcome and they expect to get back to their preinjury efficiency no matter how severe the injury.

After the introduction of Locking compression plates by AO in 2000, its popularity has been continuously rising to the point where almost all distal femur fractures are being treated only with these angle stable implants.

The LCP is a single beam construct where the strength of its fixation is equal to the sum of all screw-bone interfaces rather than a single screw's axial stiffness and pullout resistance in unlocked plates. Its unique biomechanical function is based on splinting rather than compression resulting in flexible stabilization, avoidance of stress shielding and induction of callus formation. It can also be used as biological fixation without disturbing the fracture site. Its efficiency in addressing osteoporotic bones has come as an added advantage. Early surgical stabilization has helped in early mobilization which is required for preventing complications like knee stiffness.

Anatomically precontoured low profile plates reduced soft tissue problems and there is no need for plate contouring. LCP combi-holes combine a dynamic compression unit (DCU) hole with a locking screw hole permitting an internal plate fixation using standard screws, locking screws or a combination of the two.

Angular stability provided by the construct prevented screw loosening as well as primary and secondary loss of reduction, allowed early functional mobilization, preserved vascularity of the bone, and offered improved purchase in osteoporotic bone.

In fractures with intraarticular comminution, due to the multiple screw options multiple fragments can be reduced with improved stability which cannot be achieved by using the conventional implants like DCS which uses only one large lag screw. Also revision surgery can be done easily in LCP whereas in DCS if a revision surgery is planned the removal of the lag screw leaves a cavity in the condylar area which renders it difficult for fixation and even if fixation is done, chances of failure is more due to poor bone stock.

We followed the NEER scoring system for functional evaluation as it gave equal importance to practical (pain, disability), clinical (shortening, knee flexion) and radiological (angulation) parameters. We obtained 55% excellent, 25% good, 10% fair and 10% poor outcome with this system.

In our study, radiological union was seen at an average of 16.5 weeks which is comparable to study of LISS plates by Max Markmiller, et al, CORR,2004, that averages 13.8 weeks. Overall results were good to excellent in 16 out of 20 cases and were fair to poor in remaining cases. The overall average knee score in our study was 76.6 units, as apposed to 81units in J.M. Siliski et al, study,JBJS. The range of knee motion was 30-130^{o} which is comparable to the study by Kregor PJ Standard, JA Zlovodzki, PA publication of early results of LCP in 103 fractures in September 2005.

Swashbuckler approach is a novel approach to address comminuted intraarticular fractures where good visualization of the entire articular surface is required. In the three Type C3 fractures which were approached through this approach, we obtained excellent outcome in 2 patients and good outcome in 1 patient due to achievement of articular congruency.

The outcome seems to correlate with certain functions. In cases of severe intraarticular comminution, the outcome depends on the quality of reduction intraoperatively. Good reduction with < 2mm articular incongruence is required for good outcome.

There were two compound injuries in our study and both the patients had poor outcome. One patient developed deep infection while the other patient developed knee stiffness probably due to soft tissue injury at the time of initial injury. Hence, compound fractures should be treated aggressively but with guarded prognosis.

One patient with Type A1 fracture had vascular complication post-operatively. This fracture pattern is usually associated with a sharp spike and hence it should be carefully handled intraoperatively failing which it may cause damage to the popliteal vessels. Also traction should be applied so that soft tissue contracture will be minimal at the time of surgery in case the surgery is prolonged due to associated co-morbidities.

Comparison of results of distal femoral fractures treated with LCP obtained by other studies

Author	Number	Type A %	Type C %	ROM°	Deep Infection %	Removal due to Pain %	Implant Failure %	Outcome (Excellent & Good)
Kregor et al	66	50	50	2-103	3	-	1.5	-
Schutz et al	99	67	33	0-107	7	-	6	-
Markmiller et al	20	50	50	0-110	-	-	10	87.5%
Apostolou et al	19	30	55	0-108	5	-	5	81.25%
Yeap & Deepak et al	11	55	45	1-107.7	-	-	9	72.7%
Our Study	20	35	65	0-130	5	-	-	80%

The comparison with other studies for distal femoral LCP as mentioned in the above table has shown similar results. The mean range of motion was 0-130 degrees which is similar to the other studies . The incidence of deep infection was 5%, occurring in one of the two cases of compound injury. Implant failure has not occurred in our series while it has occurred in 10% cases in the other series of 20 patients fixed with this implant. The percentage of patients with excellent and good results was 80% which is comparable and similar to the 81.25% obtained by Apostolou et al. None of the patients had to be subjected to implant removal just as in the other series.

Of the 12 male cases 9 were due to RTA while travelling in a two wheeler. Of these 9 cases, 8 cases involved the dominant Right side which reflected the increased two wheeler population in our country and the left sided driving regulation that is being followed.

Varus malalignment was one of the complication which was encountered during the study. It was countered by the technique of maintaining gap between the plate and the proximal fragment. Also using lengthier plates rather than using small plates resulted in reduced rate of this complication.

Osteoporotic fractures respond well to this implant if the proper principles of management are followed. This is evidenced by the Excellent outcome in a 87 year old female patient with type C2 fracture and also as also the other elderly patients.

The length of time elapsed from injury to surgery correlated inversely with the outcome. Also the presence of concomitant injuries and comorbidities had a definite impact on the interval for surgery and the postop rehabilitation thus affecting outcome.

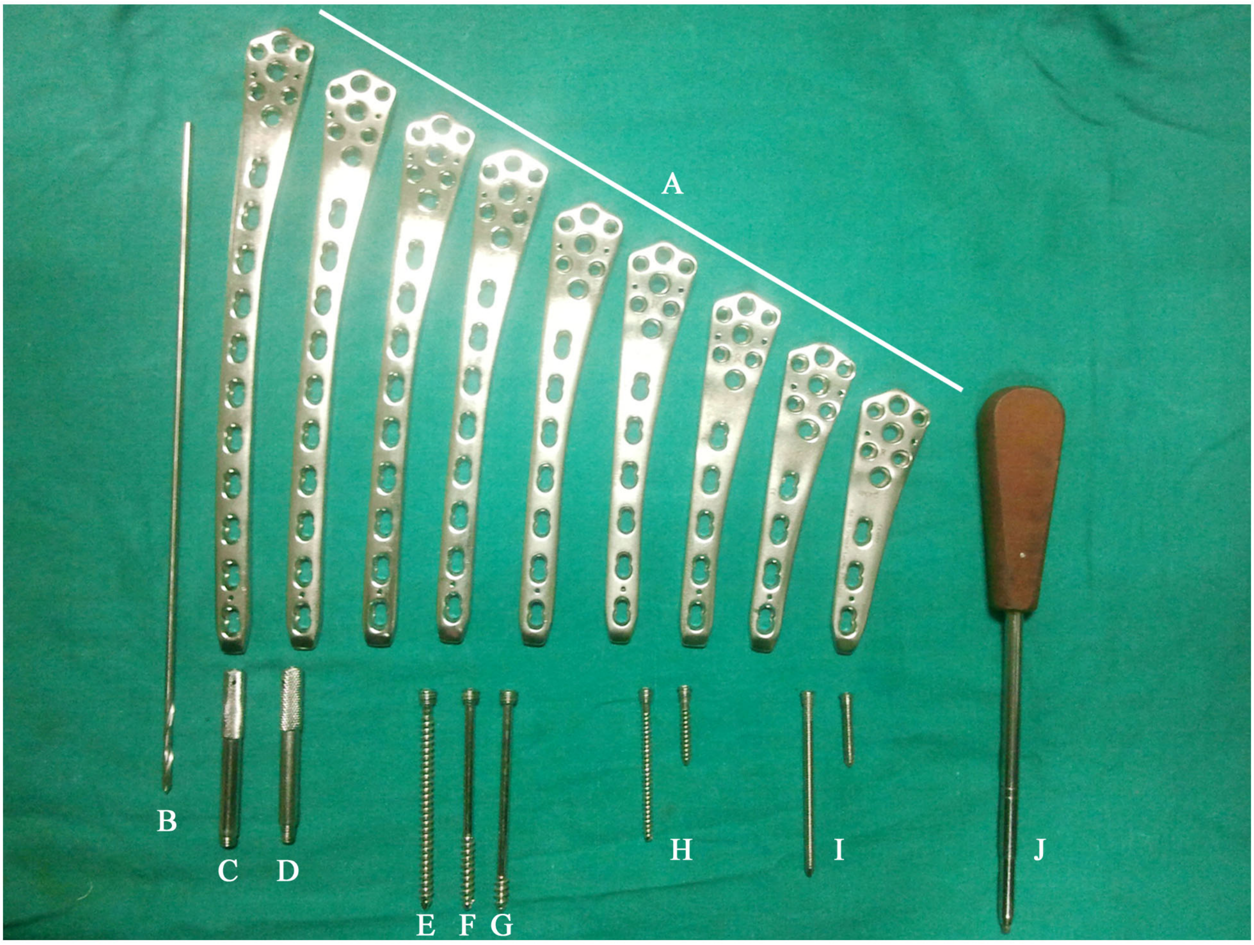
The definitive long term prognosis remains unknown as of today, as the earliest LCP was implanted in the mid to late1990's.

Though the locking plates can fail when physiological loads are outside plate-design parameters, our study did not show any case with such an outcome. This probably indicates that the implants were of high quality. Also, if we ensure that weight bearing is started only after definite radiological union as in our study, then implant failure can be avoided.

CONCLUSION

The evolution of implants for the fixation of distal femur fractures has come a long way and at present, the latest in the armamentarium is the Distal Femur Locking Compression Plate. It provides a sound answer to the age old problems of varus collapse, osteoporotic bone, malunion and nonunion though it does not completely eliminate them. Complications may occur, but if the principles of fixation are properly adhered to, Distal Femur Fractures need no longer be a cause of apprehension for the Orthopaedic surgeon. These fractures can be treated aggressively and satisfactory functional outcome should rather be a norm in these cases.

IMPLANTS



A – DISTAL FEMUR LOCKING COMPRESSION PLATE

B – 4MM DRILL BIT

C – 6.5MM DRILL SLEEVE

D – 5MM DRILL SLEEVE

E – 6.5MM FULLY THREADED LOCKING CANCELLOUS SCREW

F – 6.5MM 32MM THREADED LOCKING CANCELLOUS SCREW

G – 6.5MM 16MM THREADED LOCKING CANCELLOUS SCREW

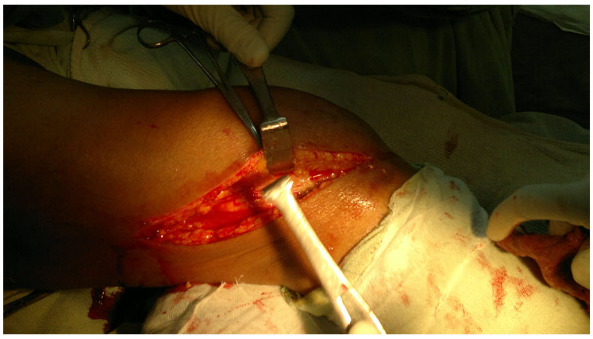
H – 5MM FULLY THREADED LOCKING CANCELLOUS SCREW

I – 5MM LOCKING CORTICAL SCREW

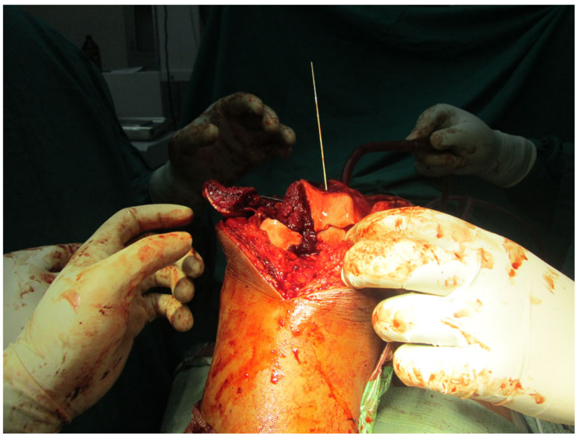
J – SCREW DRIVER

SURGICAL PROCEDURE

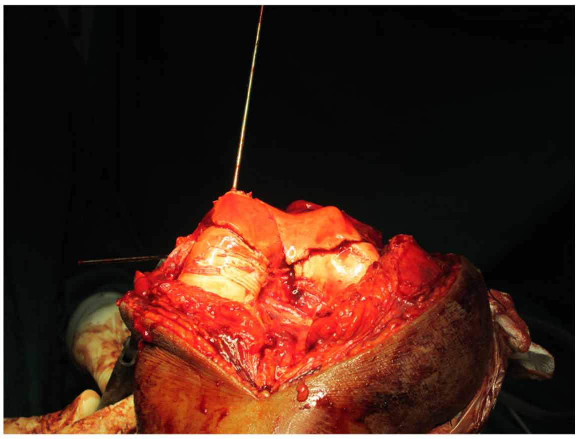
PATIENT POSITION



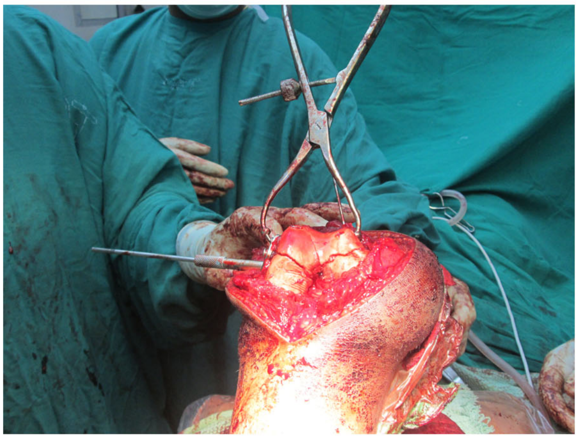
INCISION



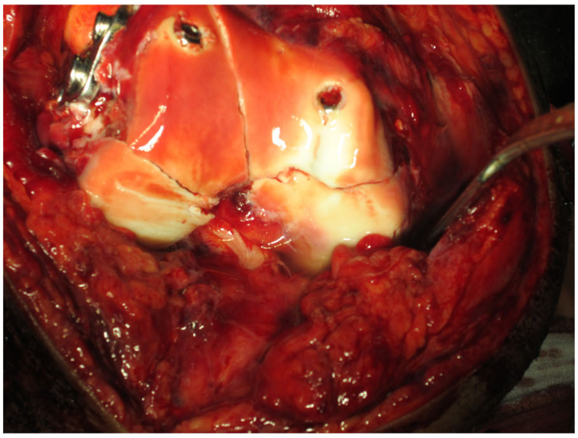
TEMPERORY K WIRE FIXATION



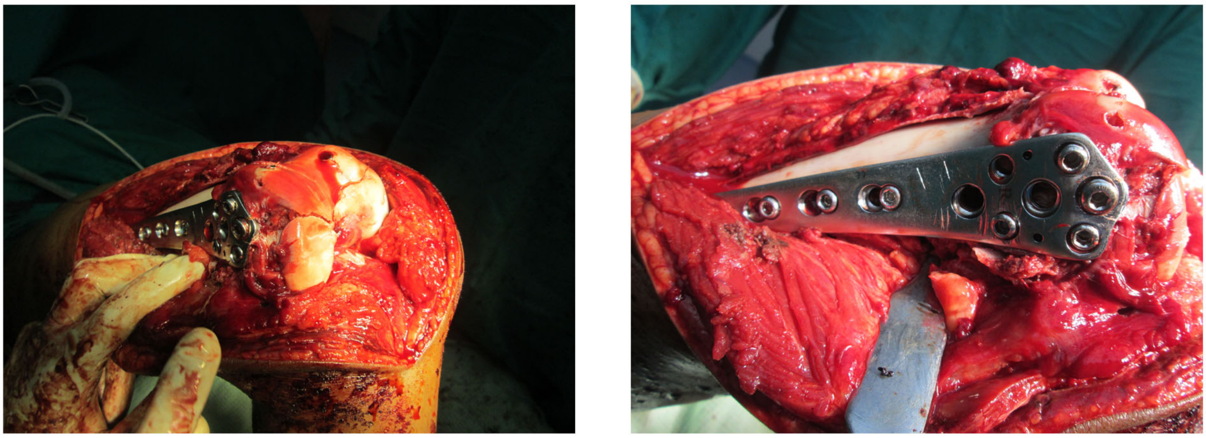
TEMPERORY K WIRE FIXATION



REDUCTION WITH CLAMP



FIXATION WITH CANCELLOUS SCREW



REDUCTION OF CONDYLE TO THE SHAFT WITH PLATE

WOUND CLOSURE

1. BIBLIOGRAPHY

1. Supracondylar fractures of adult femur, A Study of 110 cases. Charles S.Neer, S.Ashby Grantham and Marvin L.shelton, Journal of Bone and Joint Surgery Am.june 1967; 49: 591-613.

2. Surgical treatment of displaced ,comminuted fractures of the distal end of the femur.RD Mize, RW Bucholz and DP Grogan, Journal of Bone and Joint Surgery Am.1982;64:871-879.

3. Supra condylar-intercondylar fractures of the femur. Treatment by internal fixation, JM Siliski, M Mahring and HP Hofer, Journal of Bone and Joint Surgery Am,1989;71:95-104.

4. The Results of Open Reduction and Internal Fixation of Distal Femur Fractures Using a Biologic (Indirect) Reduction Technique. Bolhofner, Brett R.*; Carmen, Barbara; Clifford, Philip + Journal of Orthopaedic Trauma. 10(6):372-377, August 1996.

5. New technique for treatment of unstable distal femur fractures by locked double-plating: case report and biomechanical evaluation. Jazrawi, L M /93 Kummer, F J / Simon, J A / Bai, B / Hunt, S A / Egol, K A / Koval, K J , The Journal of trauma, 48 (1), p.87-92, Jan 2000.

6. AO Philosophy and Principles of Fracture Management-Its Evolution and Evaluation. David L. Helfet, Norbert P. Haas, Joseph Schatzker, Peter Matter, Ruedi Moser, and Beate Hanson. J. Bone Joint Surg. Am., Jun 2003; 85: 1156– 1160.

7. Less Invasive Stabilization System for treatment of distal femur fractures. Ricci, Anthony R / Yue, James J / Taffet, Robert / Catalano, John B / DeFalco, Robert A / Wilkens, Kenneth. American journal of orthopedics (Belle Mead, N.J.), 33 (5), p.250-255, May 2004.

8. Femur – LISS and Distal Femur Nail for Fixation of Distal Femoral Fractures, Max Markmiller, MD, Gerhard Konrad, MD, and Norbert Sudkamp, MD. Clinical Orthopaedics and Related Research Number 426, pp 252-257, September 2004.

9. Treatment of Distal Femur Fractures Using the Less Invasive Stabilization System: Surgical Experience and Early Clinical Results in 103 Fractures. Kregor, Philip J. MD *; Stannard, James A. MD +; Zlowodzki, Michael MD ++; Cole, Peter A. MD, Journal of Orthopaedic Trauma. 18(8):509-520, September 2004.

10. Locking Compression Plate loosening and plate breakage, A Report of 4 cases, C.Sommer, R.Babst, M.Muller, B.Hansan, Journal of orthopaedic trauma September 2004:18:571-577.

11. The Association Between Supracondylar-Intercondylar Distal Femoral Fractures and Coronal Plane Fractures, Sean E. Nork, Daniel N. Segina, Kamran Aflatoon, David P. Barei, M. Bradford Henley, Sarah Holt, and Stephen K. Benirschke J. Bone Joint Surg. Am., Mar 2005; 87: 564 – 569.

12. Biomechanics and clinical application principles of locking plates. Christopher Sommer, Head of traumatology, Kantonsspital, Switzerland, Suomen Orthopedia ja Traumato logia vol. 29. Jan.2006, pages.20-24.

13. Locked Plates Combined With Minimally Invasive Insertion Technique for the Treatment of Periprosthetic Supracondylar Femur Fractures Above a Total Knee Arthroplasty. Ricci, William M. MD; Loftus, Timothy BA; Cox, Christopher BA; Borrelli, Joseph MD, Journal of Orthopaedic Trauma.20(3):190-196, March 2006.

14. Failure of LCP Condylar Plate Fixation in the Distal Part of the Femur. A Report of Six Cases. Heather A. Vallier, Theresa A.

Hennessey, John K. Sontich, and Brendan M. Patterson,J. Bone Joint Surg. Am., Apr 2006; 88: 846 - 853.

15. Operative Treatment of Acute Distal Femur Fractures: Systematic Review of 2 Comparative Studies and 45 Case Series (1989 to 2005). Zlowodzki, Michael MD; Bhandari, Mohit MD, MSc; Marek, Daniel J. MD; Cole, Peter A. MD; Kregor, Philip J. MD, Journal of Orthopaedic Trauma. 20(5):366-371, May 2006.

16. Principles of fixation of osteoporotic fractures, P. V. Giannoudis and E. Schneider, J Bone Joint Surg Br, Oct 2006; 88-B: 1272 - 1278.

17. Locking compression plate: a new concept in fracture management. Orthopaedics today Vol VIII No.4 Oct-Dec.2006, pages 197-207.

18. The Evolution of Locked Plates. Erik N. Kubiak, Eric Fulkerson, Eric Strauss, and Kenneth A. Egol, J. Bone Joint Surg. Am., Dec 2006; 88: 189 - 200.

19. Biomechanical analysis of distal femur fracture fixation: fixed-angle screwplate construct versus condylar blade plate. Higgins, Thomas F / Pittman, Gavin / Hines, Jerod / Bachus, Kent N, Journal of orthopaedic trauma, 21 (1), p.43-46, Jan 2007.

20. Results of Polyaxial Locked-Plate Fixation of Periarticular Fractures of the Knee. George Haidukewych, Stephen A. Sems, David Huebner, Daniel Horwitz, and Bruce Levy, J. Bone Joint Surg. Am., Mar 2007; 89: 614 - 620.

21. Femoral Supracondylar Malunions with Varus Medial Condyle and Shortening. Wu, Chi-Chuan MD. Clinical Orthopaedics & Related Research. 456:226-232, March 2007.

22. Management of Open Fractures and Subsequent Complications. Charalampos G. Zalavras, Randall E. Marcus, L. Scott Levin, Michael, J. Bone Joint Surg. Am., Apr 2007; 89: 884 - 895.

23. Fractures of lower extremity, A.Paige Whittle,George W.Wood II, Terry Canale, chapter 51,Campbell’s operative orthopaedics,10th edition, pp. 2805 - 2825.

24. Fractures of distal femur, Peter J. O’brien, Robert N. Meek, Piotr A.Blachut and Henry, Rockwood and Green’s Fractures in adults, 6th Edition, Vol 2, pp.1916 – 1967.

25. Frigg. R, Locking Compression plate, An osteosynthesis plate based on the dynamic compression plate and the point contact fixator, Injury journal 32 S-B 63-66.

26. Last’s Anatomy, the knee joint and osteology, 10th edition, pp. 130-135, 163- 165.

27. Gray’s Anatomy for Students, Richard.L.Drake, Wayne Vogl, Adam W.M.Mitchell, Pg 513-515

28. Greene: Netter's Orthopaedics, Walter . B. Greene,1st ed.,Chapter 17, Anatomy and Biomechanics of Hip and Knee

29. AO Manual of Fracture Management, Michael Wagner, Robert Figg – Internal Fixators – Concepts and Cases using LCP and LISS, Pg 559-622

30. AO Principles of Fracture Management C. L. Colton, A. Fernandez Dell‘Oca, U. Holz, J. F. Kellam, P. E. Ochsner

PROFORMA

Name : Age/Sex: IP No.:

Address:

Phone No.:

Date of Admission:

Date of Surgery:

Date of Discharge:

Fracture Type:

Mode of Injury:

Side of Injury:

Open / Closed Injury:

Associated Co-Morbidities:

Associated Injuries:

Investigations:

Advise on discharge

Follow up and Complications

Functional outcome

Treatment and Rehabilitation

MASTER CHART

S.NO	AGE	SEX	MODE OF INJURY	CLOSED/OPEN	SIDE	MULLER TYPE	INTERVAL FOR SURGERY	ASS.INJURY	COMORBIDITIES	KNEE FLEXION	UNION TIME	COMPLICATIONS	OUT COME
1	43	MALE	RTA	CLOSED	RIGHT	C2	7	NIL	NIL	130	14	NIL	EXCELLENT
2	87	FEMALE	ACCIDENTAL FALL	CLOSED	RIGHT	C2	12	NIL	HTN	110	17	MALUNION	EXCELLENT
3	32	MALE	RTA	CLOSED	RIGHT	C2	9	NIL	NIL	100	18	NIL	GOOD
4	40	MALE	RTA	OPEN	RIGHT	C2	9	I/L BB LEG,C/L BB LEG	NIL	30	19	KNEE STIFFNESS	POOR
5	62	FEMALE	ACCIDENTAL FALL	CLOSED	RIGHT	A1	7	NIL	HTN/DM	100	17	NIL	EXCELLENT
6	60	FEMALE	RTA	CLOSED	RIGHT	A1	11	I/L BB LEG	HTN	80	18	NIL	FAIR
7	70	MALE	RTA	CLOSED	RIGHT	A2	5	I/L TALUS FRACTURE	COPD	130	15	NIL	EXCELLENT
8	65	FEMALE	ACCIDENTAL FALL	CLOSED	RIGHT	A1	21	NIL	HTN/DM	50	19	VASCULAR INJURY	FAIR
9	65	FEMALE	RTA	CLOSED	LEFT	C3	9	I/L TIBIAL PLATEAU FRACTURE,C/L BB LEG	HTN	100	16	NIL	GOOD
10	27	MALE	RTA	OPEN	RIGHT	C2	7	HEAD INJURY	NIL	40	18	INFECTION	POOR
11	38	FEMALE	RTA	CLOSED	RIGHT	C1	16	NIL	NIL	110	16	NIL	EXCELLENT
12	43	MALE	RTA	CLOSED	LEFT	C2	5	NIL	NIL	100	15	NIL	GOOD
13	61	MALE	RTA	CLOSED	RIGHT	C1	11	NIL	DM/IHD	130	15	NIL	EXCELLENT
14	45	MALE	RTA	CLOSED	RIGHT	C3	5	NIL	NIL	120	17	NIL	EXCELLENT
15	55	MALE	RTA	CLOSED	RIGHT	C2	9	I/L TIBIAL SHAFT FRACTURE	IHD	120	17	NIL	EXCELLENT
16	34	MALE	RTA	CLOSED	RIGHT	A3	5	I/L BB LEG	NIL	90	16	NIL	GOOD
17	65	FEMALE	ACCIDENTAL FALL	CLOSED	RIGHT	A1	6	NIL	DM/HTN/IHD	100	17	MALUNION	GOOD
18	63	FEMALE	ACCIDENTAL FALL	CLOSED	LEFT	A1	5	NIL	IHD	120	15	NIL	EXCELLENT
19	36	MALE	RTA	CLOSED	RIGHT	C3	11	NIL	NIL	120	15	NIL	EXCELLENT
20	42	MALE	RTA	CLOSED	LEFT	C2	21	NIL	NIL	110	16	NIL	EXCELLENT